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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

VOL II.

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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. II.] 1890. [Part 1.

I.—Proposed Petrological Classification for the Rocks of New South Wales: by T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor.

It is proposed to divide the rocks of New South Wales into three groups, *Sedimentary, Eruptive, and Altered.*

The term Sedimentary, as used by the Survey, will include not only sediments deposited from water, but also those deposited from the air, such as are formed from the dust-storms prevalent at the Barrier Ranges and elsewhere in the Western plains of New South Wales, as described by Mr. C. S. Wilkinson, Geological Surveyor-in-Charge.

The term will further include all wind-formed (Æolian) rocks, whether wholly formed by wind or partly by wind, and partly by water, though it is very doubtful whether any true representatives of the former class exist in New South Wales, which is a sufficient reason for not separating the Æolian from the water-formed rocks. The term *Sedimentary* appears to be preferable to Aqueous, and to Clastic or Fragmental, for the term Aqueous is a less comprehensive term than the one proposed. To the terms Clastic and Fragmental it can be objected that they introduce at once among Sedimentary rocks Eruptive rocks, such as tuffs, which seems unnatural; and further, if these terms be used, the term Crystalline must be employed antithetically; and the latter term necessitates the grouping together of rocks of such widely dissimilar origin as granite, marble, and rock-salt.

It may be objected to the term Sedimentary that it is not strictly applicable to masses of rubble and talus at the foot of precipices, but it is of course impossible to find any single term not open to some objection, and the term Sedimentary seems the least objectionable one under which to include the classes of rock ranged under it in the present scheme. No provision is made in the scheme for extra-terrestrial rocks, such as meteorites and cosmic dust, but they may be grouped by themselves under the head of extra-terrestrial rocks. The dolomites of New South Wales, which as described by C. S. Wilkinson, have a thickness in the Barrier Ranges of about five hundred feet, have been classed provisionally with the chemically formed Sedimentary rocks, but it is doubtful whether they had not better be placed in the B division of the Altered rocks.

As regards the term *Eruptive* it appears to be preferable to the terms, *Igneous*, *Hydrothermal*, and *Crystalline*, for Igneous is obviously a misnomer in its Latin acceptation, meaning fire rather than heat, certainly not moist heat; *Hydrothermal* has the objection of being as equally applicable to the altered rocks as to the Eruptive,; and an objection to the term *Crystalline*, besides those already mentioned, is that it excludes all the glassy types of Eruptive rocks from the rest of the Eruptives, which is an unnatural separation.

As regards the sub-divisions of the Eruptive rocks, the first two proposed are the Massive and the Tuffaceous. Massive is adopted here rather than Crystalline, because Crystalline excludes the glassy types. An alternative term for Tuffaceous is Pyroclastic, but the same objection applies to Pyroclastic as to Igneous, viz., that it is a misnomer as regards its signification of the agency of fire. It may be objected that Tuffaceous is liable to be confounded with Tufaceous, and perhaps it might be better to substitute the term Tuffs for Tuffaceous, but the adjective Tuffaceous is preferable as opposed to the adjective Massive.

As regards the classing of the glassy or vitreous types of rock there exists at present a considerable looseness of nomenclature among petrologists, arising naturally from the greater difficulty of differentiating volcanic glasses as compared with the holocrystalline eruptives, of which they are the representatives, from the absence of any well-defined crystallised minerals in the volcanic glasses. Thus the term Pitchstone is often applied to probably glassy varieties of trachyte and andesite, as well as to obsidians and rhyolites, which two last are of course true representatives of the acid group.

Similarly the term tachylyte is loosely used to express glassy representatives probably of all the different varieties of basaltic rocks, usually occurring in a microcrystalline or holocrystalline condition.

Some doubt may be entertained as to the propriety of retaining diabase as a division separate from the basic dolerites, instead of grouping it under the latter rocks, as the finely crystalline varities of diabase when of a volcanic character

nearly approach the plagioclose-basalts on one side, and the augite-andesites on the other. An objection also to using the term diabase at all is that by some petrologists it is used as a term for a crystalline granular admixture of triclinic felspar, augite, and magnetite, in which olivine is not, and has, perhaps, never been, present; whereas by others it is used for dolerites which have lost their olivines simply through decomposition, and which, consequently, show in transparent sections under the microscope only triclinic felspar, augite, and magnetite, with various products of alteration representing the decomposed olivine, and often pseudomorphous after it. For such dolerites the adjectival form diabasic should probably be employed. It may, however, be as well for the present to retain the old term diabase, restricting its use to the undecomposed rock consisting of a crystalline granular admixture of triclinic felspar, augite and magnetite, and not employing the term at all unless there appear to be strong reasons for it. In some cases the so-called diabases of this Colony can certainly be referred to coarsely crystalline conditions of dolerite.

Various inconsistencies must exist at present in all classifications of the Eruptive rocks by reason of the very little that is known as to the essentials, which should be taken as constituting distinct rock species, and the present scheme of classification is not free from them.

An inconsistency exists in the attempt to subdivide the massive Eruptive rocks strictly in accordance with their mineralogical constitution. For instance, as pointed out by Professor J. W. Judd,* in the case of some of the lavas termed enstatite-andesites, from Krakatoa, as compared with similarly named rocks from America, Santorin, and England, although these rocks are so classed chiefly on account of their mineralogical constitution, they nevertheless differ widely in ultimate chemical composition, as he shows by the following table:—

	Rocks of Santorin dykes.	Buffalo Peaks lava.	Cheviot Rocks.	Recent lavas of Santorin.	Rocks of Krakatoa.
Silica	51·8	56·6	64·5	67·4	70·0
Alumina	20·1	16·2	16·3	14·8	15·0
Oxides of Iron	11·6	9·3	5·1	6·4	4·0
Lime	11·9	7·8	4·4	3·7	3·7
Magnesia	3·4	4·6	4·2	1·0	1·3
Soda	1·1	3·1	3·4	4·4	4·1
Potash	0·1	2·4	3·1	2·3	1·9

These inconsistencies in classifications, based purely on mineralogical constitution, show the necessity for making ultimate chemical composition the primary basis of subdivision of the Massive Eruptives, and making mineralogical constitution subordinate to it, though even this system of making chemical composition the primary basis of division will obviously have to be abandoned if further research proves it to be unnatural.

* Geol. Mag., 1888, Dec. III, Vol. V, No. 1, p. 4.

The Tuffaceous rocks are proposed to be divided into ***Simple*** and ***Compound.*** Simple Tuffs are defined as being composed purely of Eruptive rocks. It is also possible, however, of course, for some Tuffs to be composed purely of Sedimentary rocks, and some purely of Altered rocks, like clay slate. Examples, however, of Tuffs of this kind are so rare that it appeared hardly necessary to reserve a special class for them.

Altered Rocks.—The term *Altered* appears preferable to the old term *Metamorphic*, as the latter implies that an actual change of form has taken place in the minerals composing the rock, which very inadequately and often incorrectly describes the changes which have taken place, which are more often of a metasomatic rather than of a metamorphic character.

It is proposed in the accompanying scheme to divide the Altered rocks into two groups—(1) those whose origin is known, and (2) those whose origin is unknown.

In the former group are included (1) altered Sedimentary rocks, recognisable as such: (2) Altered Eruptive rocks, recognisable as such, and referable to the particular varieties of Eruptive rocks from which they have been derived, whether Massive or Tuffaceous. For instance, it can be shown in many cases that compact quartzites have been derived from sandstones, lydian stones from mudstone, graphitic slates and schists from carbonaceous clays, hematite and magnetite schists from the alteration of sandy bog-iron ores, apatite rocks probably from ancient coprolite beds or guano deposits, gneisses from the marginal crushing of granite, felsitic slate and schist from pumiceous tuffs, diabasic schists from diabasic tuffs, some mica schists from arkose sandstone.

In such cases as these it might therefore be as well to refer the rock at once to the variety of unaltered rock from which it has been derived.

By far the greater portion, however, of the altered rocks of New South Wales cannot at present be referred to any recognised type of unaltered Sedimentary or Eruptive rock with any certainty. For them, therefore, some provisional arrangement becomes necessary, and it is proposed accordingly to keep them in a group by themselves.

The question of sub-dividing this group is a somewhat difficult one, but the most obvious primary differentia is the chemical composition. It would, however, be impracticable to attempt at present to divide the altered rocks of intermediate composition from those of basic. The test of the presence or absence of free silica, so useful, especially in the field, in classing the rocks of the acid eruptive group, fails when applied to the altered rocks, for the tendency in these, as in all rocks appears to be, whenever conditions are favourable for rearrangement of material, for acidic minerals such as the felspars to break up into more basic minerals, especially micas, with separation of silica. This change is very observable in the tuffaceous sandstones and conglomerates of the Rhacopteris beds of the Port Stephens District,

in which secondary mica has been largely developed apparently at the expense of the basic material in the finely comminuted fragments of felspar, and this has probably been accompanied by a separation of silica, as in the case of the arkose sandstones and shists of Lake Superior. Some of these crystals of secondary mica in the Rhacopteris beds are over half inch in diameter.

Mr. Howitt's observations in the Omeo District also show that the crushed felspathic material in the gneisses formed from granites has altered into mica and free silica, which is quite in accord with the artificial experiments of Messrs Fouqué and Michel-Lévy, who found that powdered felspars on heating, under dry heat, formed mica and quartz on recrystallising after cooling, instead of recrystallising as felspar. The conclusion to be drawn from this, therefore, is that free quartz may be expected in the altered rocks even when they have an ultimate chemical composition which is intermediate or even basic. Only, therefore, in the case of those Altered rocks whose composition is decidedly siliceous is it proposed to include them under the acid-eruptive group, such as gneiss, granulite, quartz, schist, &c. At the extreme basic or ultra-basic end of the list serpentine, whether foliated or not, may be safely placed, and the altered rocks of intermediate or basic composition, such as epi-diorite, chlorite rock, chlorite schist, talc schist, sericite schist, &c , may be temporarily included under one group, as proposed in the scheme.

Granite and gneiss have been included doubtfully under the acid Altered rocks. This is contrary to the most recent researches of the bulk of petrologists, who maintain that there is never a passage from a Sedimentary rock into a granite. Against this, however, must be adduced the fact that intrusive granite is occasionally found immediately underneath rocks even of secondary age, not merely in dykes, but even in broad eruptive masses, as in the Vancouver Series of the Dominion of Canada, where instrusive granite immediately underlies Triassic rocks. Obviously these Triassic rocks must have been laid down on an old floor of Sedimentary or Eruptive rock, and what, then, can have become of that floor unless it has been gradually dissolved and absorbed into the mass of the eruptive granite, in the same manner as the fragments of the Triassic rocks, entangled in the granite along its junction line with the Trias, are described as having been partially absorbed.*

The following description of the relation of the granite of Vancouver Island to the Triassic Vancouver Series has such an important bearing on the classing of the Altered rocks that there is sufficient excuse for quoting Dr. Dawson's words here, as follows:—"The circumstances attending the line of junction of the granites with the rocks of the Vancouver Series have been carefully examined at a great number of points. The granites near this line are usually charged with innumerable darker fragments of the Vancouver Series, which, when in the immediate vicinity of the parent rock, are angular and clearly marked, but at a greater distance become

* On a Geological Examination of the Northern part of Vancouver Island and adjacent coast. Geol. Nat. Hist Survey Canada, Ann. Report, 1886 II. Report B., pp. 11-13, by Dr. G. M. Dawson.

rounded and blurred in outline, and might then be mistaken for concre
masses in the granite, into the substance of which they have been in pro
being absorbed. The width of the belt characterized by these fragments
variable, and where the plane of the present surface cuts that of the junc
the two classes of rocks at an acute angle, as is often the case, it is consi
frequently exceeding half a mile."

The possible conversion of Sedimentary rocks into granite as above su
by Dr. Dawson, is confirmed by Mr. A. C. Lawson's observations on the
of the Lower Archæan (Laurentian) to the Upper Archæan, as studied
Lake of the Woods and Rainy Districts, over an area of about thirty th
square miles. Mr. A. C. Lawson concludes that the intrusive nature
Laurentian rocks along their junction line with the Upper Archæan is du
Laurentian rocks, at a time subsequent to that when they formed the
which the Upper Archæan were deposited, having passed into a state of
the superincumbent Upper Archæan remaining unfused.*

Such observations as these justify the retention of a place, temporarily
rate, for some granites and some gneisses among the altered Sedimentary ro

The expediency of including rocks altered merely by somewhat su
weathering, such as laterite, palagonite tuff, melaphyre, and wacke am
Altered Rocks may seem questionable. Deposits of kaolin might with eq
priety, perhaps, be also so classed.

It might subsequently be found to be convenient to distinguish betwe
altered by chemical action set up by air and rain water, down to a compa
shallow depth, and rocks altered by deep-seated chemical action.

This scheme of classification is intended only as a tentative one to be
provisionally for classing the rocks of New South Wales, and to be modified
to, or completely recast, wherever it can be proved to be at variance with
Appended are:—

(1) Scheme of Classification for the Rocks of New South Wales.

(2) Lettering of Formations to be used for Maps and Sections
Geological Survey of New South Wales.

(3) Signs to be used for Maps and Sections by the Geological Su
New South Wales.

The scheme of colours for the geological maps and sections is almost
agreed upon, and will shortly be published.

* Congrès Géologique International, 4me Session—Londres, 1888. Etudes sur les Schistes cristallins, pp

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Siliceous.

(Itacolumite.)
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(Altered sandstone.)

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LETTERING OF FORMATIONS TO BE USED FOR MAPS AND SECTIONS BY THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

ALTERED—

A. Altered rocks whose origin is known to be marked with the letter or symbol of the rock, whether eruptive or sedimentary, from which they have been derived.

B. Whose origin is unknown ... X

SEDIMENTARY—

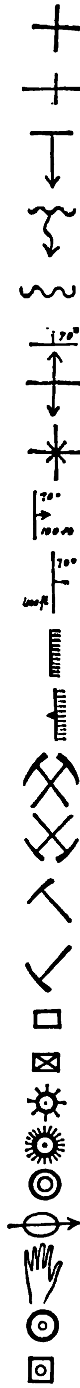
CAMBRIAN	P
SILURIAN	Ps[1], Lower. Ps[2], Upper.
DEVONIAN...	Pd[1], Lower. Pd[2], Upper.
CARBONIFEROUS	Pc[1], Lower. Pc[2], Upper.
PERMO-CARBONIFEROUS	Pp[1], Lower Marine Series. Pp[2], Greta Series. Pp[3], Upper Marine Series. Pp[4], Tomago Series. Pp[5], Hexham Series. Pp[6], Newcastle Series.
TRIASSIC	Mt[1], Narrabeen. Mt[2], Hawkesbury. Mt[3], Wianamatta.
CRETACEOUS	Mc[1], Lower Cretaceous (Rolling Downs of Queensland). Mc[2], Upper Cretaceous (Desert Sandstone and Maryborough beds of Queensland).
TERTIARY	Te, Eocene. Tm, Miocene. Tp, Pliocene. Ti, Pleistocene. Tr, Recent.

ERUPTIVE—

The lettering or symbols for the rocks of this class in New South Wales have not yet been agreed upon, but will, it is hoped, be detailed in a subsequent paper, which will also specially deal with the question of the Geological Terms and Nomenclature employed by the Geological Survey of New South Wales.

SIGNS TO BE USED ON MAPS AND SECTIONS BY THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Signs.



Horizontal stratification.

Vertical beds, the longest line showing the strike.

Angle and direction of dip of inclined strata.

General dip of undulating beds.

Contorted strata.

Dip and strike of cleavage.

Anticlinal axis.

Synclinal axis.

Normal fault.

Reverse fault.

Reef of which dip is unknown.

Reef dipping (angle read from horizontal).

Mine being worked.

Mine abandoned.

Quarry being worked.

Quarry abandoned.

Shaft being worked.

Shaft abandoned.

Fresh-water spring.

Mineral or mud spring.

Point of eruption (carmine circle).

Glacial striæ.

Cave shelters.

Artesian well.

Bore.

II.—On the Occurrence of the Genus *Tryplasma*, Lonsdale (*Pholidophyllum*, Lindström), and another Coral apparently referable to *Diphyphyllum*, Lonsdale, in the Upper Silurian and Devonian Rocks respectively, of N. S. Wales: By R. ETHERIDGE, Junr., Palæontologist.

[Plate I.]

I.—*Genus* TRYPLASMA.

IN describing* his proposed genus *Pholidophyllum*†, Dr. G. Lindström made the following remarks respecting Lonsdale's *Tryplasma*. It "should perhaps have been called *Tryplasma*; but this name having been founded upon a false conception, according to which the septal points and septal plates should be perforated with canals, a supposition caused by the broken lower parts of the points, I proposed the new name . . . . . based upon the peculiarities of the outer scales." I regret that I cannot agree with Dr. Lindström in the abolition of *Tryplasma*. If every generic name in Palæontology is to be abolished because an original misconception as regards its structure was made, few of the older genera would stand. Granting that a genus has been figured and described to the best of an Author's knowledge, and the material before him, to say nothing of his selecting a well known species as the type, it seems difficult to understand, how in common fairness his work can be set aside. I therefore adopt *Tryplasma* as typified by Lonsdale,‡ and described by Lindström under the name of *Pholidophyllum*, with this exception.—I believe that *Palæocyclus* should be eliminated from the synonyms of the latter.

Dr. Lindström unites with *Tryplasma* (*Pholidophyllum*), a genus described by Dr. W. Dybowski§ under the name of *Acanthodes*, a union in which I cordially agree, failing to see how they can possibly be separated.

From the Upper Silurian rocks of the neighbourhood of Yass we possess a coral in which we find the character of *Tryplasma* repeated, but with specific differences. This will be spoken of throughout the following remarks as *Tryplasma Lonsdalei* (Pl. I., Figs. 1 to 6).

The corallum is in the condition of a rather loose aggregation of long, slightly flexuous, cylindrical corallites gradually increasing in size upwards from a finely pointed base united laterally by connecting tubes or stolons (Pl. I., Fig. 1) after the manner of the genus *Eridophyllum*, with an average length of three sixteenths of of an inch. The stolons do not appear to have any particular direction of curvature in growth, but are generally horizontal, and are present in all parts of tho

* Bihang K. Svenska Vet. Akad. Handl. Stockholm, 1882, VII, No. 4.
† Öfver K. Vet. Akad. Forhandl. Stockholm, 1870 [1871], p. 925.
‡ Murchison's Geol. Russia, &c., 1845, I, p. 613.
§ Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 108.

corallum, from the base upwards, placed at different heights, and not generally passing from corallite to corallite on the same level, although this has been noted in one or two cases. The stolons previous to their junction with the corallites are somewhat swollen or enlarged, decreasing in the middle (Pl. I., Figs. 2 and 5); they are hollow, having a similar proper wall to the corallites, not being merely epithecal out growths. Here and there the corallites impinge against one another, through the absence of the stolons; but on the whole the growth of *Tryplasma Lonsdalei* is tolerably regular.

The circular corallites have an average diameter of three-sixteenths of an inch, but at the points of issue of the stoloniferous out-growths the diameter increases to four and five-sixteenths of an inch. The longest corallites observed were three and a-half inches long.

The epitheca is thin, produced into knobs and small processes, but never presenting regular accretion growths or concentric frills, whether single or successively cupuliform as in some other Upper Silurian forms of this genus.

Parietal gemmation is visible in a few instances, and when the corallites are not too crowded, the younger ones spread out from the parent at rather a wide angle.

The internal structure of this coral is typically that of *Tryplasma*, both as figured by Lonsdale and Lindström, the septa playing a very subordinate part as compared with the tabulæ, the latter not reaching completely across the visceral chambers, as I have failed to trace any definite connection between them and the proper wall; in fact there appears to be very little union between the tabulate and septal zones (Pl. I, Fig. 2 and 3). They are very numerous and close, at times a little irregular, often with a slight concavity, and frequently possessing a slight central depression or pit.

The septa are represented by a series of upwardly directed, short, rigid, thorn-like spines projecting into the visceral cavity between each pair of tabulæ for about one-third the width of the corallite (Pl. I, Fig. 2). As many as three tiers are observable in each inter-tabular space, forty septa in a cycle (Pl. I, Fig. 5), alternately primary and secondary, but the difference in length of the two orders is not great. In a horizontal section the septa appear much broken up and dot-like (Pl. I, Fig. 3), which arises from the section having cut the upwardly projecting ends of more than one cycle. Similarly, when a vertical section is made close to one or other of the walls, and excentric, the distal ends of the septa again appear as so many disconnected points. In clearly preserved specimens the sides of the septa appear to be frosted by a coating of microscopic denticles.

One of the chief points brought forward by Lonsdale in his description of *Tryplasma*, consists "in the lamellæ" (*i.e.* the septa) "of the outer area being pierced from the inner surface of the wall through the whole breadth by well

defined relatively large foramina, terminating on the inner edge in a distinct row of short tubuli. The presence of such structures appears to be doubted by Lindström, and I believe, rightly so. Lonsdale, it is true, remarks "that the outer envelope was never pierced," but a curious expression is made use of by Dybowski, who says that in his *T. Eichwaldi** the septa do not appear as points, but as a small roundish or oval holes, arranged in longitudinal rows. Is it possible that these are simply the so-called pores of Lonsdale? It would seem to be so, because further on, Lonsdale, as I understand him, appears to regard the foramina as leading into hollow septa. Whatever may be the condition of the European specimens, I can assert, after a long examination of various cross sections of our Australian species, that the septa are perfectly homogeneous in structure, and that no part of the proper wall is perforate. On the other hand, examples occur in which an undoubted apparent poriferous appearance is presented, quite as figured by Lonsdale. Such are visible in our Pl. I, Fig. 4, on the lower left-hand portion of the figure, arranged in longitudinal series between vertical continuous ridges. I was for a long time much perplexed how to account for this obviously different structure. The following explanation will, I think, meet the case. The "pores" are only visible on entirely, or partially decorticated specimens, *i.e.*, on those in which the epitheca and the proper wall, with the septal area, are wholly or in part removed. Now, bearing in mind that the septa are separte thorn-like bodies, which, from the individuality of the tabulate area, would become readily detached, with those portions just mentioned, it naturally follows that the septa would leave their casts or impressions on any earthy matter infilling the intertabular spaces, or which might have intruded itself between the septal and tabulated zones during decomposition or subsequent fossilisation. In fact, I have a specimen which has lately come into my hands from Hatton's Corner, which more or less shows this. The ridges seen in Pl. I, Fig. 4, between the lines of "pores," are, it follows from this, the infilling casts of the longitudinal interseptal loculi. Another point which tends to bear out this view is the fact that, in all vertically weathered or decorticated specimens, the edges of the tabulæ are left exposed, showing the little cohesion which existed between the septal and tabulate areas.

It will now be of interest to compare our coral with *Tryplasma æquabilis* and *T. tubulatum*, the types, acknowledged by Lonsdale in 1845,† and Lindström in 1882. The latter describes two varieties of this species designated by him "*forma primaria*" and "*mutatio*." In the first, the form of the corallum is broad-conical, the width often greater than its length. In the second variety, on the other hand, the corallum is cylindrical. Our species appertains to the latter variety and generally resembles in habit the coral so figured by various authors, as given in Dr.

* Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 117.

† Lonsdale also mentions as a species of his proposed sub-genus the *Cyathophyllum articulatum*, His., sp. from Gotland, but Dr. Lindström has shown that this is not Hisinger's species, and has included it as a synonym of his *Pholidophyllum tubulatum*.

Lindström's synonomy. We possess no evidence yet that the Australian form was fixed during life by "stolon pipes" (Stolonrören), from the base of the corallum, as in the European species; but from the presence of these organs throughout the other portions of the corallum it is but natural to suppose that they existed also for the purpose in question;* at the same time, Dybowski does not figure such rootlets attached to any of the cylindrical (or "mutatio") species of his *Acanthodes*. At first sight the stolons of *T. Lonsdalei* resemble the horizontal uniting bars of *Eridophyllum*, which are also outgrowths of the proper wall, and this is especially the case in those *Eridophylla* in which the central tabulate area is highly developed, but an examination of the respective septal systems at once dispels any preconceived analogy. If I mistake not, uniting stolons are visible in one of the figures of the corals believed by Lonsdale to be *T. articulatum*†, the central corallite of the figure being united to that on the right hand by two, whilst Dybowski illustrates this structure only in one instance, his species *Acanthodes tubulus*‡.

In the "*forma primaria*," or broadly conical variety of *Tryplasma* (*Pholidophyllum*) *tubulatum*, as understood by Lindström, the exterior of the corrallum was ornamented by "epithecal scales," compared by this author to the opercular valves of *Goniophyllum*, *Aræopoma*, and other similar genera, and which are said to exist in the compound forms only at times. It is evident also from Dybowski's illustration of *T.* (*Acanthodes*) *rhizophorus* §, that anchoring stolons existed in this section of the genus. Our specimens of *T. Lonsdalei* being in a great measure denuded of epitheca, little chance has remained for the preservation of these delicate organs.

The septa in the Australian fossil are much less in number than in *Tryplasma tubulatum*, Schl., sp., the former possessing just half those of the latter, or forty in all, twenty primary and twenty secondary; whilst the resemblance between those of *T. Lonsdalei* and the four species figured by Dybowski is very marked. In all the specimens before me the septa appear to be thorn-like, laterly granular, with an upwardly-directed course, a feature as equally well displayed in the Australian as the European fossils, but the length of the septa is apparently a more constant character than in *T. tubulatum*.

The tabulate area is very characteristic in all species of *Tryplasma*, but like Dr. Lindström, I have quite failed to detect any trace of a septal fossula. Dybowski says that in his *T. cylindricus* the tabulæ cease at the inner ends of the septa, and do not reach the proper wall. He accounts for this on the supposition that the septa are too closely placed to one another, and in well prepared thin sections of *T. Lonsdalei* I have not distinctly observed the tabulæ uniting with the proper wall. The tabulæ of the latter species resemble those of *T. rhizophorus*,

* This is highly probable, because stoloniferous rootlets are a characteristic feature and common to many "Anthozoa Operculata."
† Murchison's Geol. Russia, &c., 1845, I, t. A., f. 8b.
‡ Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 114.
§ *Loc. cit.* t. A, f. 12.

Dyb. sp. and *T. Eichwaldi*, Dyb. sp. more than they do the other species of the genus, and appear to be of the simpler structure in *T. tubulum*, Dyb. sp. In the last-named coral, *T. rhizophorus*, *T. Eichwaldi*, and *T. tubulatum*. Schl. sp., several tiers or cycles of septa occur between every pair of tabulæ, in which *T. Lonsdalei* agrees with them, but in *T. cylindrica* there appears to be a tabulum for each septal cycle.

From the closely intermingled state of the corallites in the blocks from Hatton's Corner it is difficult to distinguish the method of reproduction, but so far as observed the regular calicular gemmation described by Lindström has not been observed. On the contrary, two or three instances certainly demonstrate the presence of parietal budding, thus favouring the description of Lonsdale, who says:—"Chiefly from the sides of the parent stem." Dybowski describes a lateral or parietal gemmation, and figures it in *T. tubulum*, but at the same time remarks on its rarity of occurrence.

In the form of growth Dybowski's genus *Cyathophylloides*,* especially *C. fasciculus*, Kutorga,† is a similar coral, the somewhat flexuous corallites being united by stolons as in the present instance. The nature of the septa, however, entirely separates the two genera, for in *Cyathophylloides* the septa converge to the centre of the corallites, and the open tabulate area is not present. The latter does not seem to me to differ in any important characters from *Diplophyllum*, Hall.‡

II.—Genus DIPHYPHYLLUM.

The adverse opinion of such eminent authorities as Milne Edwards, and Haime, notwithstanding, *Diphyphyllum* has been shown by Messrs. De Koninck, Billings, Nicholson, and Thomson, to be a valid genus, and distinct from *Lithostrotion*, thus confirming the original statement of Mr. W. Lonsdale.§

In this genus the corallum is compound, formed of long, usually cylindrical corrallites united in more or less fasciculate groups. Each corallite is clothed in a distinct epitheca. The internal structure is biareal, consisting of an outer and usually well developed septal zone, and an inner tabulate area, but the septa never reach the centre of the visceral chamber, although they may, to some extent, infringe on the tabulate area. The interseptal loculi are occupied by dissepiments, and there is no columella. The developement is by parietal or calicular gemmation.

In the coral from Tamworth (Pl. I, Figs. 7-11), collected by Mr. D. A. Porter, and about to be described, the corallum is in the form of very long, slender, and somewhat delicate cylindrical corallites, usually free, but united by their walls at times, and thus forming loosely fasciculate aggregations. The corallites possess an average diameter of three millimeters.

* Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 123.
† See Roemer, Lethæa Geognostica, I Thiel, Leth. Pal., lief. 2, 1883, p. 340, f. 67.
‡ Pal. N. York, 1852, II. p., 115.
§ Murchison's Geol. Russia &c., 1845, I, p. 622.

In cross section (Pl. I, Figs. 8 and 9) there is revealed a very delicate outer wall, which rapidly becomes destroyed, leaving the proximal ends of the septa projecting as a series of spike-like extensions (Pl. I, Fig. 9), or when seen on the exterior of a weathered specimen, as vertical lamellæ. The septa are about twenty-eight in number, of equal length, and extending inwards barely for half the diameter of the corallites, and dying out on the central tabulate area (Pl. I, Figs. 8 and 9). Here and there one seems to be longer than its fellows, but there is an entire absence of secondary septa in the true sense of the word. The interseptal loculi are divided by two continuous cycles of dissepiments (Pl. I, Figs. 8 and 9), which are so regularly continuous as to give support to the late Professor de Koninck's view of the existence of an inner wall.*

The tabulate area occupies nearly two-thirds of the entire diameter of the corallites, and is destitute of the acicular central point described as occasionally existing by Lonsdale.† The interseptal loculi between the outer delicate wall and the first cycle of transverse dissepiments invariably appear in cross section to be quite free of subdivisions.

A longitudinal section is equally instructive. The labulæ are horizontal or oblique; complete, or at times incomplete, their inner edges resting on one another, and then giving to the corallum a more or less vesicular appearance (Pl. I, Figs. 10 and 11). When complete, however, they always appear equidistant, and usually possess the Diphyphylloid character of a downward curvature at the periphery, a character pointed out in this genus by Prof. M'Coy.‡ On the other hand, there is again no trace of the central break in the tabulæ, resulting in what Mr. James Thomson calls the "columellarian line"§, when a number of tabulæ are arranged in serial succession, and a continuation of Lonsdale's acicular point. The inner zone is filled with minute very close transverse dissepiments, and convex upwards, or in the direction of the general growth of the corallum (Pl. I, Fig. 10). In a longitudinal section nearer the periphery the vertical and continuous septal lamellæ are at once seen, subdivided into a ladder-like appearance by the transverse dissepiments previously described.

The epitheca is not preserved, and the method of reproduction has not been observed, but from the appearance of the two contiguous corallites (Pl. I, Fig. 8) it would not appear to differ from the method met with in the other species of the genus.

On comparing the structure of this coral with that of *Diphyphyllum*, we notice a community of structure in the biareal form of the corallum, general mode of growth, absence of a columella, presence of the central tabulate area, and the

* Nouv. Rech. Anim. Foss. Terr. Carb. Belgique, 1872, Pt. 1, p. 35.
† Murchison's Geol. Russia, &c., 1845, I, p. 624.
‡ Brit. Pal. Foss., 1851, Fascic. 1, p. 88.
§ Development and Generic Relation of the Corals of the Carboniferous System in Scotland, p. 37 8vo., Glasgow, 1883).

peripheral downward inclination of the tabulæ. On the other hand, the present coral departs from the general structure of *Diphyphyllum* in the much less amount of vesicluar tissue, and the somewhat abnormal method of its arrangement, giving rise to the impression that an inner mural investment was actually present. It further differs in the uniform size of the septa, and the delicate outer wall.

In general outward appearance our specimens (which I purpose calling *Diphyphyllum ? Porteri*) are very much like Hall's genus *Diplophyllum*,* but in the latter the septa are said to pass completely to the centre of the visceral chamber, accompanied by other minor details. In this sense *Diplophyllum* does not appear to differ from *Fascicularia*, Dybowski, and even from *Donacophyllum*, Dybowski.† The specimens were collected by Mr. D. A. Porter, from the Devonian limestones of the neighbourhood of Tamworth, N. S. Wales.

III.—Notes on the Tertiary Deep Lead at Tumbarumba: By WILLIAM ANDERSON, Geological Surveyor.

NEARLY thirty years ago the Tumbarumba valley was extensively worked for gold, which was obtained, chiefly from the Pleistocene and Recent gravels and sands, deposited by the present creek. The gold was no doubt largely derived from the denudation of portions of the Tertiary lead which exists within the drainage area of that creek, although much of it had probably been thrown from reefs in the bed-rock which had undergone denudation during the erosion of the present valley.

The country in the neighbourhood of Tumbarumba is of a somewhat mountainous character, and the varied physical effects produced by the denudation of different kinds of rocks are well seen in the district. Away to the westward of the valley the denudation of the Silurian rocks has produced a smoothly undulating country, well covered with soil of fairly good agricultural quality; while to the eastward, where the country is wholly composed of granite, it has been eroded into rugged gorges, and rough, wild, bare, cliff-girt mountains of forbidding aspect, with poor grass and sparse timber. The Tertiary basalt which extends from near the point where it had junctioned with the Maracle Deep Lead basalt, northward to near Bago, is very narrow, and produces, by its degradation, rich agricultural soil. In the vicinity of Bago Inn, the basaltic plateau is, however, of considerable width and elevation (being over three thousand feet above sea level), and here the quality of the soil

* Pal. N. York, 1852, II, p. 115, t. 33, f. 1, &c.
† Mon. Zoantharia Sclerodermata Rugosa aus der Silurformation Estlands, &c., 1873, p. 80.

is shown by the immense size of the timber growing upon it. The depth of the soil is considerable, and has been fully taken advantage of by innumerable wombats, whose burrowings make it extremely dangerous to ride over the surface.

To the east of Tumbarumba Creek there is a wide development of granite, while to the west of it the country is formed of Silurian slates. These latter have been tilted and indurated to a considerable extent, but in the immediate neighbourhood they have not undergone any further alteration, although towards the Murray River considerable metamorphism has taken place. No fossils have yet been obtained from these slates, but it is very probable that they form a part of the Upper Silurian series which is so largely developed further to the eastward. The granite is probably intrusive, if one may judge from the comparatively slight degree of alteration which is apparent in the slates in the neighbourhood of the junction between the two rocks, but the immediate line of contact cannot be observed in the valley of the Tumbarumba Creek, because it is concealed from view below the Tertiary basalt which covers the deep lead. The Tertiary valley, now represented by the deep lead, has been eroded for a long distance in the vicinity of Tumbarumba, along the junction-line between the granite and the slate. Such contact lines offer less resistance to the eroding action of stream-water than otherwise intact rock masses do, and therefore the main direction of many river eroded valleys often follow them with great persistance. The eruption of the lava which partially filled the Tertiary valley seems not to have affected the general level of the country to any appreciable extent, for the main line of drainage still remains approximately the same, and the Tumbarumba Creek, doubtless for some time, continued to flow down the Tertiary valley on the top of the basalt, but ultimately the waters found it easier to erode a passage through the granite, which formed the eastern valley slope; and now we find the upper and greater part of the present valley excavated in that rock. A short distance below the township, however, the creek has worn its way through the basalt and crossed to its western edge, and from this point to its junction with Burra Creek the present valley has been eroded in the Silurian slates, having the basalt for its western slope.

In positions where sections of the lower part of the basalt can be seen it has a columnar structure, while the upper part of the flow is compact. It never attains any great thickness. In one section, exposed on Macabe's Creek, to the south of the township, there is, apparently, a distinct line of demarcation between the lower columnar, and the upper compact basalt. It is, therefore, probable that there were two lava flows, one following rapidly upon the other. Macroscopically the rock is, as a rule, fine-grained and compact, of a greyish-black colour, having small macroscopic crystals of olivine scattered through it. It presents the general appearance of a Tertiary basaltic lava. Microscopically (Slides Nos. 69 and 70) it consists of an aphanitic base, formed of triclinic felspar, augite and magnetite, among which a few large porphyritic crystals of olivine are developed. Minute

patches of glass are present in the base. The olivines are much cracked, but otherwise slightly altered, only small portions of the crystals having undergone serpentinisation, which, under a high power, has a minutely reticulated appearance for a varying distance from the cracks into the fresh olivine. There are no striking microscopical features to particularise this rock from the general run of Tertiary basalts.

The granite varies much in texture, but is, as a rule, moderately coarse-grained, although occasionally it is locally largely porphyritic. Its general colour is whitish-grey, the felspar and quartz, speckled with black mica. It is an easily degraded rock, and is readily shattered when slightly decomposed, because the crystals of its various constituents are but loosely held together. Microscopically it consists of two kinds of felspar, orthoclase and a triclinic felspar, which is probably albite, quartz and mica, with a little chlorite, which may be altered hornblende. Exceedingly fine needles of apatite occur as inclusions in the other minerals. Some of the triclinic felspars show a zonal polarisation, and they generally contain a good deal of opaque dusty matter arranged along their twinning planes. The mica assumes two forms, one a light, almost colourless variety, showing the striations very distinctly, and a dark-brown variety, in which the striated character is lost. There is little doubt that the latter is an alteration of the former, because in some sections the clear striated mica is seen to pass into the darker unstriated form.

In many of the large denuded granite blocks lying on the surface, and also in naturally exposed sections of the granite small dark-coloured patches occur, which at first sight were readily mistaken for aggregations of mica, &c., but, on closer examination, their outlines were found to be well-marked and they possessed a generally ellipsoidal form. In size they vary from a few inches in their longer diameter to as much as a couple of feet, and very often they have a distinctly laminated appearance, the laminæ being usually parallel with the longer axis. Microscopically they have all the appearance of rounded pieces of sedimentary rock which have undergone considerable alteration. In microscopical section (slides Nos. 73, 74, 75) they are seen to be distinctly crystalline in structure, and the apparent lamination is due to the arrangement of the various minerals in alternate layers. The rock is quite distinct from the granite and consists of quartz and mica, the flakes of the latter mineral being arranged in a linear manner parallel to the longer axis of the fragments. The dividing line between the two rocks can readily be traced under the microscope, and the minute quartzes and micas of the finer grained rock fill up the minute bays left between the larger crystals of the granite, but in no instance are any of the larger granitic crystals completely surrounded by them. In Slide No. 73, the central portion of the fragment consists chiefly of quartz, with green coloured hornblende, while towards the periphery it is much finer grained, and contains the ordinary brown mica. This rock, therefore, differs widely from

the other fragments and from the general granitic rock in which it occurs, as there is little or no primary hornblende in the granite, although there is some chlorite which might be an alteration of hornblende. These laminated fragments in the granite are at present in the form of mica—and hornblende—schists, and from their composition and mode of occurrence, they would seem to be oreign to the granite. They may be the remnants of the original rocks from the melting of which the granite was formed, or they may be the altered remains of masses of the strata through which the granite was intruded, which were caught up by it when in a liquid state. They are certainly not aggregations, nor is it likely that they are crystallisations of the fluid magma from which the granite was finally crystallised. It is just possible, however, that they may be the residue of a previous local crystallisation before the magma was finally consolidated into its present granitic form, and that the laminated appearance may be due to local pressure induced by the subsequent final consolidation of the granite. They are altogether unlike any of the slatey sedimentary rocks that occur in the district, and among which the granite has been intruded. Although there is, to a certain extent, an intercrystallisation between them and the granite, yet the dividing line between the two rocks is distinctly recognisable, and their peripheral structure differs in a slight degree from that of their centres, thus showing that crystallisation had taken place in these two positions under different conditions, the peripheral zone being more affected by the outside fluid granitic magma than the central part. I have noticed occurrences, similar to the above, in the granite which covers a large area in the neighbourhood of Moruya, in the southern coastal district; while in a granite which occurs between Bendemeer and the Northern Railway line, I have observed masses of highly-altered sedimentary rocks, which have undoubtedly been caught up by the intruding granite, and which have not wholly undergone liquefaction, but remain as identifiable sedimentary rocks, although considerably altered.

The general course of the Tertiary river valley is well defined by the run of basalt, although the latter does not now, in its whole course, cover the channel proper, because it has been denuded so unequally upon both edges of the flow, that in many places merely the basalt which covered portions of the sides of the Tertiary valley is present, the greater part of the drift having been denuded away with the overlying basalt, and its contained gold having been thrown into the Pleistocene alluvium of the present valley. At the northern extremity of that portion of the basalt known as the "Sounding-ground," the basalt as seen on the map is Y-shaped, one arm passing northward towards Tarcutta Creek and the other passing up the Tumbarumba Valley, while the area between these two arms is occupied by a high granite mountain. Some two miles south of "Bago Inn" there is a small lake in the basalt the water of which seldom alters its level. This probably represents one of the points of eruption from which the lava flowed. The flow proceeded southwards, and passed round the eastern side of the above mentioned

granite mountain to the south of which the old valley took a somewhat sharp turn to the south-eastward. At this point it flowed against the western side of the valley, which presented itself almost at right angles to the direction of flow. The main bulk of the lava continued its course further down the valley, but a considerable portion of it took a north-westerly course, and flowed backwards for some distance up the valley, lying to the west of the granite mountain. The junction of these two valleys represented by the basalt at the base of the two arms would therefore be a good place to prospect.

The deep lead represented by the flow of basaltic lava has been, as yet, very little worked. Most of the work that has been done in the district has been in the washing of the gold from the Pleistocene drifts in the present valley, in which the quantity of gold has been largely augmented locally by the denudation of portions of the Tertiary Lead. This work has chiefly been carried on by utilising the waters of the creek whose course has been locally turned for the purpose of sluicing certain areas of drift in its neighbourhood. What little work has been done on the lead itself has been by sluicing by means of head races, which have been carried for long distances down the sides of the valley. There are only a few points in the course of the lead where this has been done, so that those portions of it which still exist under the basalt are practically untouched. At one spot, some distance below the township, a shaft has been sunk through the basalt on the lead, but payable drift has not yet been struck there. At various points along the denuded edges of the basalt perennial springs flow from below it. These are probably natural outlets for the drainage, either of the drifts in the gutter proper, or of pervious beds among the pipeclays, and they would therefore be favourable positions for prospecting the deep lead by means of tunnelling. It will doubtless also be found, as indeed has already proved to be the case at Laurel Hill, that there will be positions where the lead rests on the granite, the decomposition of which has gone on to a sufficient depth to allow of its being sluiced away below the level of the channel, and thus making it possible to work the drift by sluicing, the columnar character of the basalt at the bottom of the flow lending itself readily to removal by the force of the water, because of the amount of decomposition that has gone on along the polygonal joints.

The accompanying geological sketch map shows the denuded edges of the Tertiary basalt, with the drifts, consisting chiefly of sands, cropping out from under it at various places. It will be seen that for a considerable part of its course the basalt still covers the junction between the slates and the granite. So far as is known the granite of this district is not auriferous; that is to say, that gold is not one of its mineral constituents, although gold-bearing reefs occur in the granite in various places. It has been proved undoubtedly that the drift in this Tertiary Deep Lead is auriferous, because in the few positions where it has been worked it was found payable. In the upper part of the lead between the "Sounding Ground"

and Bago it is probable that all the gold in the drift must have been derived locally from the denudation of the granite and its contained auriferous reefs. The Pleistocene alluvial deposits in that portion of the valley of Tarcutta Creek, north-west of the the "Sounding Ground," have been extensively worked, and produced considerable quantities of gold. The junction between the granite and the slates passes down this part of the creek for a considerable distance, and it is probable that most of that gold has been derived from reefs and lodes which had occurred in connection with this denuded junction-line, while a certain portion of it may have been derived from the denudation of the upper part of the western arm of the deep lead which passes to the north-west of the "Sounding Ground." It is also likely that gold-bearing reefs and lodes may have occurred along the junction-line now buried under the basalt, and along which the Tertiary valley was eroded, and that their denudation during the excavation of the Tertiary valley may have produced large quantities of gold which was thrown into the drifts now forming the lead south of the "Sounding Ground."

IV.—The Aboriginal Rock-Carvings at the Head of Bantry Bay, Middle Harbour, Port Jackson: By R. ETHERIDGE, Junr., Palæontologist.

[Plate II.]

It is very desirable that authentic information should be obtained before it is too late from persons who have long resided amongst the Aboriginals, and have become conversant with their language and peculiarities. (R. B. Smyth, Aborigines of Victoria, 1878, II., p. 232.)

I.—Introduction.

OF the numerous traces of Aboriginal Rock-Carvings to be seen on the shores of Port Jackson, none probably equal in extent or completeness of detail those on the heights at the head, and on the eastern side of Bantry Bay, Middle Harbour.

The following notes were obtained during a visit to the locality made in company with Mr. G. H. Barrow, of the Australian Museum, when we made carefully measured drawings of the more important figures delineated. Previous to this, however, some years ago, Messrs. Barrow, R. Jenkins, and H. Barnes visited the carvings on behalf of the Australian Museum, and obtained similar drawings, which were afterwards photographed by the latter, and through the kindness of the Curator of the Museum a set of the photographs were supplied for our guidance,

and were found of considerable assistance, although in some matters of detail they are inaccurate. The purely Ethnological aspect of many of these drawings has been treated of by Dr. A. Carroll, in a series of interesting articles in the *Centennial Magazine*,* but so far as I am aware no systematic attempt has been made to describe them in detail. Dr. Carroll's articles are illustrated by wood-cuts, apparently taken from the Museum photographs, as some of them display corresponding inaccuracies of detail.

Similar carvings are not uncommon on many headlands in Port Jackson and on the east coast. A few years ago Sir Charles Nicholson, LL.D., read a Paper before the Anthropological Institute "On some Rock Carvings found in the neighbourhood of Sydney,"† which are very similar to those about to be described. They were discovered by Colonel Vigors during the erection of the battery at Middle Head. "On clearing away the superficial soil and brushwood preparatory to the levelling of the rock, the carvings were brought to light . . . . . . They were covered with several inches of vegetable mould." The carvings consisted of the human form; a whale, upwards of thirty feet long; a jumping kangaroo; fish, and other objects.

II.—Locality of the Carvings.

The carvings are visible on a gently inclined surface or table of Hawkesbury Sandstone on the Public Recreation Reserve [R. 41, 6th Oct., 1879.], immediately at the roadside, leading from the Middle Harbour ferry west of the south-east corner of J. C. Rutter's triangular ten-acre portion, Parish of Manly Cove. The road runs along the summit of the ridge, immediately above the right-hand arm of Bantry Bay, which forms the watershed of the gullies, draining on the east into the Pacific above Manly, and on the west into Bantry Bay.

The table of sandstone over which the carvings are scattered measures two chains in one direction by three in the contrary, and has a gentle slope of seven degrees to the south-west. The high road as now laid out passes over a portion of them. The remains of nineteen carvings are distinctly visible, but there are others partially obliterated, and it is possible that additional ones may be hidden by encroaching low scrub and moss which is fast covering up the face of the table.

III.—Description.

The figures, as in all similar cases which have come under my notice, are represented in their present state, in outline by a continuous indentation or groove from one to one and a half inches broad, by half an inch to one inch in depth. Some are single subjects scattered promiscuously over the surface; others form small groups illustrating compound subjects, but all appear to have been executed about one and the same time.

* Vol. I., No. 1, p. 58 : No. 2, p. 89 ; No. 3, p. 187.
† Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1880, IX, p. 31.

Dr. Carroll says the figures all point in one direction, facing the rising sun. This, however, is not the case, a fact which is at once proved by some facing east, others north, and some again the west, whilst the general aspect of the table is westerly.

On leaving the road, one of the first objects discernible is represented in Pl. II, Fig. 1; a kangaroo in a horizontal position. The approximate measurements* are a height of five feet five inches by three feet nine inches; but another kangaroo, presumedly on a similar scale, must have been five feet high. This, shown in Pl. II, Fig. 2, was not visible at the time of the visit of Mr. Barrow and myself; but a sketch was obtained on a former occasion by Messrs. Barrow and Barnes. From the flank of the kangaroo a spear is projecting, and this animal is one of the commoner forms depicted in the aboriginal carvings around Port Jackson. The speared kangaroo, according to Dr. Carroll, represents the chief warrior, who employed it as his totemic sign, the spear indicating his death in a similar manner. Figs. 1 and 2 are hardly equal in execution to the cave-drawings in North-west Australia, given by Captain (Sir) G. Grey; but, on the other hand, those of men here depicted are much more proportionately drawn than those accompanying the kangaroos in the work cited.

Approximate to Fig. 1, is the partial figure of a man and an aquatic animal, probably a porpoise (Pl. II, Figs. 3 and 4). The male figure is rather more than five feet in height, the Cetacean being five feet six inches in length and nearly four feet in total width. The representation of the man is much less perfect in outline than are other male figures to be described hereafter. Immediately below, *i.e.*, lower on the sloping sandstone surface, are the outlines of a fish (Pl. II, Fig. 5), and a figure, at first of a somewhat puzzling nature. The general shape of the body and snout-like anterior end suggest the *Echidna* as a fair interpretation. It is about one and a half feet in length (Pl. II, fig. 6).

The next figure which claims our attention, and one of the most interesting of the series is Fig. 7. This object, which can be interpreted in a variety of ways, is fourteen feet long, with a rather undulating outline, a moderately well-formed head, with the eye approximately in position, and a gradually tapering body. It lies parallel with Figs. 5 and 6, but at right angles to Figs. 1 and 3. It possesses neither fins, paddles, or other locomotary appendages. Now, I think this may be supposed to represent either an enlarged figure of an eel, such as the green eel (*Muræna afra*), or a snake, or is it intended to convey an aboriginal idea of the much debated "sea-serpent"? Whatever it may pictorially display, it is certainly one of the most interesting of the series. In close contiguity to these objects is one of those carvings, which Mr. T. W. E. David and the writer have likened to shields, † and lower down the slope of the sandstone table are others.

* The measurements, although only called approximate, will be found to be substantially correct.
† Rec. Geol. Survey N. S. Wales, 1889, I, pt. 2, p. 143.

The first of these (see as in Pl. II, Fig. 9), situated near the tail of Fig. 7, has a double crossbar in the centre, but no diamond shaped divisions at the apices. In the other two "shields" the cross and longitudinal lines are single, and the diamond shaped divisions at the poles present. The general appearance (Pl. II, Fig. 8) however is again rendered dissimilar by a general diagonal obliquity assumed by the object and much greater convexity of lateral outline. The longitudinal division is also flexuous, whilst in other cases, as Fig. 9, and the figures of those observed at Forty Baskets Bay* the median line is straight and direct. Fig. 9 is itself peculiar in the possession of one divided-off apex, and a double crossbar. As before stated, although possessing but a rough resemblance to the ordinary shield or *mulga,* these objects are regarded by Mr. T. W. E. David and the writer as the representation of shields, whilst Mr. C. S. Wilkinson has suggested that they may be canoes. On the other hand Dr. Carroll explains them as the emblem of a God † and also that of fire, or even of the benificient Spirit *Ndewa*, or *Ngungi*. If such is the case, then the existing blacks also use this emblematical ornament to adorn their shields at the present day. The Ethnological Collection of the Australian Museum contains a *hieleman* [B. 1788] of hardwood with a longitudinal line in red, and two median horizontal lines, quite resembling those we see depicted in rock carvings ‡. A Queensland shield in the same collection is similarly ornamented with the addition of a ground work of red dots. I would also point out that the resemblance of these objects to the bullock-hide shields of the Zulu is a marked one. It must be candidly confessed that the size of these objects, one five feet six inches and the other more than six feet in height, is very disproportionate to the measurements of existing aboriginal shields. Fig. 10 is again open to much speculation as to its identity. It certainly is more nearly allied in shape to the shields used by some tribes; but the similarity would have been increased had one cross piece for the hand-hold been present instead of three, wherein it departs wholly from aboriginal shields. The three stretchers would incline one to regard this object as representing a canoe, for although several types of canoe undoubtedly existed amongst the blacks, one form at least was kept rigid and expanded after the manner depicted in the sculpture.§ It is five feet six inches long.

An advance on the other sculptures existing at this place seems to be made in the originals of Figs. 11*a* and *b* from the fact that an attempt was apparently made to represent a compound idea in the form of a single combat between two warriors. The figures are quite contiguous to one another. The individual seen in Fig. 11*a* seems to be holding in his right hand a body similar to that represented in Fig. 10, and the position in which it is held would lend colour to the belief in its shield-like

* Rec. Geol. Survey, N. S. Wales, 1889, t. 21, f, 1-3.

† Centen. Mag. I, No. 2, p. 90.

‡ Compare also the shields figured in Eyre's Journals of Two Expeditions of Discovery into Central Australia, &c., 1845, I (Frontispiece), and Vol. II, t. 3, f. 15. At a meeting of the Linnean Society of N. S. Wales, held on Feb. 25th, 1885, Mr. George Masters exhibited "unusually wide Hielemans" from the Herbert River, Queensland (Proc. Linn. Soc. N. S. Wales, 1885, IX, pt. 1, p. 76).

§ R. B. Smyth's Aboriginies of Victoria, 1878, I., pp. 408 and 238. Compare the figure of the canoe given in Eyre's Journals of Two Expeditions of Discovery into Central Australia, &c., 1845, Vol. II, t. 4, f. 5.

nature. In the opposite hand are a bundle of rods which have been suggested to be spears, and this explanation for the want of a better may be accepted. On the other hand we are confronted with the fact that these weapons of offence and defence are held in the wrong hands unless the holder be regarded as sinistral; otherwise it must be conceived that the warrior's back is presented to the observer, which is contrary to the other evidence existing in the carving. The opponent (Pl. II, Fig. 11*b*), with legs astride and arms outstretched, much in the position of an aboriginal when throwing the boomerang is equally definitive. I conceive it quite possible that the position of the boomerang, close to the right hand, conveys the idea that this man has just thrown the missile at the subject of Fig. 11*a*, allowing of course for the want of a knowledge of perspective on the part of the aboriginal artist. The ambiguity of the weapons held in the hands of Fig. 11*a* illustrates how difficult it is to arrive at a satisfactory conclusion as to the identity of many of these portrayed subjects; such for instance as Fig. 10. In outline, and the presence of crossbars, this is practically the same as both the above, and it is only the longitudinal lines present in one of the latter, which has given rise to the suggestion that the object portrayed is a bundle of spears.

Other peculiarities may be observed in this and like figures, such as Figs. 3 and 12. In three of these the head is a mere rounded outline, but in Fig. 11*b* it is presented with a rather bird-like appearance.

Another peculiarity is the great angularity given to the knee-cap; this is visible both in Figs. 11*a* and *b*, and Fig. 12. It is further exemplified in the elbow of the left arms of both Figs. 11*a* and *b*. The original of Fig. 11*a* is seven feet high, whilst that of Fig. 11*b* is five feet eight inches; but it has been raised too much on a level with the top of its *vis a vis* for the exigencies of the plate, as the left finger-tips in the carving on the sandstone table are on a level with the waistband of Fig. 11*a*. Dr. Carroll regards these figures as representative of *Biame*, "an ancestral spirit or god." He gives an illustration* which may be intended for this sculpture, and if so, it is very disproportionate.

Fig. 13 is a nondescript animal; it may be a dog, an opinion already advanced by Dr. Carroll, who regards both it and the subject of Fig. 15, as tokens of intermarrying subdivisions of the clan inhabiting the district in which they were carved†.

The fish seen in Fig 14 is one of three following one another in a direct line, and another above the series, with in advance of them, the object sketched in Fig. 15. Those represented by the former figures are all fairly well outlined; but the latter is a very nondescript being. By Dr. Carroll it is regarded as a catfish. There, again, from the continuity of thought displayed by these fish carvings, it seems to me we have a subject—the pursuit of the "catfish"—by the four larger forms. The latter

* Centen. Mag. I, No 1, p. 54.
† *Ibid*, I, No. 3.

average five feet in length by two feet in width. A portion of this group appears to form the frontispiece to Dr. Carroll's paper; but the single fish is placed below the three in line, instead of above, as here described.

The largest and most imposing sculpture in the collection, is the gigantic fish seen in Fig. 16, known to visitors as the "Whale." It is sixteen feet six inches in length, with a greatest width of seven feet through the last pair of fins. It is probably a shark, a fish believed by Dr. Carroll to be a god-emblem amongst the aborigines. This author figures this form with an eye, a feature we did not observe, whilst on the other hand, in his figure, a central dorsal fin is omitted* The object projecting from the snout is peculiar, and the only suggestion that the writer can offer is that it may be intended to portray an appendage similar to those surrounding the oral aperture of the Basking Sharks.

Bonwick † mentions the carving of a fish on one of the Port Jackson heads, twenty-seven feet in length; and Sadlier ‡ records a gigantic whale, carved near Dawe's Battery. At the head of the "Whale" stands the male figure, Fig. 12, with the arms expanded; but unfortunately it is nearly obliterated, and will soon be indistinguishable. It is five feet seven inches in height, and four feet eight across the stretch of the arms.

A fish differing in appearance and proportions from the preceding figures is seen in Fig. 17, whilst an excellent representation of a boomerang is shown in Fig. 18. The sharp curve recalls to mind the weapon termed by the Victorian blacks *wonguin.*§ The former may, possibly, Mr. J. Douglas Ogilby thinks, be intended for a bream.

This comprises the principal sculptures so far as they came under our observation. The remainder, although smaller, are equally interesting. Fig. 19 is, I think, without much doubt, a *womerah*, or throwing-stick, with a well-marked socket for the spear-head, and is probably broken off short in the shaft. The two remaining objects are not difficult of interpretation. Fig 20 is a large tomahawk, or hatchet, supposed to be formed of a large pebble. It is about one foot four inches in length, and the head one foot one inch across. A similar example is in the Australian Museum, from Central New South Wales, one foot two inches long, and the head about nine inches in width. The carving may well be compared to a weapon from Lake Tyers, in Gippsland, figured by the late Mr. R. B. Smyth.‖ In connection with this larger class of weapon, he says:—"The natives of some parts of Victoria had large stone axes, made of basaltic rock, which were used for splitting trees. One in my possession is eight inches in length, five inches in breadth, and two inches in thickness. It weighs 4lb. 8½oz. Implements of this size are very rare."¶ Fig. 21 is probably a waddy, rather than some form of nulla.**

* Centen. Mag. I, No. 1, p. 56. † Last of the Tasmanians, 1870, p. 48. ‡ Aborigines of Australia, 1883, p. 17.
§ R. B. Smyth's Aborigines of Victoria, 1878, I., p. 317, f. 101, p. 315, f. 99f.
‖ Aborigines of Victoria, 1878, I., p. 366, f. 173.
¶ *Ibid*, p. 361.
** Compare the Kafir *Keerie*, figured by Dr. E. H. Knight, M.A., in his "Study of the Savage Weapons at the Centennial Exhibition, Philadelphia, 1876." Ann. Report Board Regents Smithsonian Inst. for 1879 [1880], p. 216.

IV.—Mode of Production.

Scattered amongst the finished figures are some in an incomplete state, and others just commenced, revealing the method by which the aboriginal artist carved them. A series of shallow disconnected indentations were made on the sandstone surface to the required outline; these were then deepened and widened. The next process was to make similar depressions between those already completed; and these, when deepened and widened also rendered all the depressions confluent, forming a continuous groove representing the outline.

V.—Nature of the Carvings.

The late Mr. R. B. Smyth remarked of the Victorian aborigines, "that they possessed the power of conveying ideas by a sort of picture writing is beyond doubt. Picture writing indeed was common long before Europeans made encroachments in any part of the island-continent. . . . . The native not only was able to convey ideas in this manner, but occasionally made pictures, intelligible to all, representing events in his life."* Touching the indications of their presence left by the blacks in Victoria, he adds:—"Even now, as we travel through the country, we find but few indications of a previous race having occupied it. Two of these are the marks cut on trees, which will soon disappear; and the 'native ovens,' or *mirnyongs*."† Others described by Mr. Smyth in another part of his work‡ are stone *miamys* or shelters, circular or otherwise, found throughout Western Victoria. Extending these remarks so as to include vestiges of the aborigines of New South Wales, and to all intents and purposes other parts of Eastern Australia, we may now, with our present knowledge, add to the above three other indications, viz.:—

a. Rock carvings.
b. Rock drawings.
c. Tree carvings.

The remains described in this paper will naturally fall into the first category (*a*),§ and with others of a similar nature will form a monument to the powers of imitation well known to exist amongst that race, which has been so erroneously placed amongst the lowest of mankind.

VI.—Antiquity of the Carvings.

There naturally arises the question—Are these sculptures the work of the historical blacks, now rapidly dying out? or, are they vestiges of a pre-existing section of the same race? The known natural reticence of the blacks has always rendered the acquisition of reliable information concerning their arts and mysteries a very difficult task. So far close inquiry amongst a number of gentlemen who

* Aborigines of Victoria, 1878, I. p. 286.
† *Ibid* II., p. 232. ‡ *Id.* p. 235.
§ Weapons and other implements, being outside the scope of the present inquiry, are not included here

were intimately connected with the aborigines in the earlier days of colonization has quite failed to ascertain (*a*) that similar carvings have ever been seen in course of production; and (*b*) that any black known to them had a knowledge of such work in active operation.* These facts alone lend a certain amount of antiquity to these remains, although *inter se* they do not appear to indicate a remote date of execution, the subjects delineated being all those with which the later blacks were well acquainted.

Drawings absolutely known to have been the work of aboriginals since our occupation of the continent are of quite a different character, and bear evidence of the influence exerted on the mind of the black by his association with the white man. In this sense, compare the picture drawn by "Tommy Barnes," an Aboriginal of the Upper Murray, given by Smyth.† The men's heads, pendant coat tails, pipe in mouth, &c., are quite sufficient tests to fix the period of its execution, and the great difference which exists between such drawings, and those works of art represented by the Bantry Bay carvings. In this sense I think they must be looked upon as of a period anterior to the British occupation, and therefore, perhaps representative of an early existing branch of the Australian Black as we now know him. Much the same line of reasoning has been adduced by the late Mr. R. B. Smyth in the case of the gigantic Native Ovens scattered throughout Victoria. The enormous size attained by some was believed by him to indicate their great antiquity, and by analogy that of the builders. Touching the exact period of these sculptures, it is of course impossible to chronologically fix it, but I am quite in accord with Dr. Carroll, who remarks:‡ "Some must be very old, as the indented lines bear exactly the same appearance as the surface of the rock on which they are made . . . . while chippings made near them, in the same rocks, ninety years ago by surveyors and others look obviously modern by comparision. The carvings must therefore have been made hundreds of years before the first Europeans visited Australia."

Sir Charles Nicholson writes in similar language. He says §:—"As to the age of these remains, it is difficult to form any opinion. From the extent of the erosion to which those have been subjected, which have been exposed to the open air, as well as from the depth of the alluvium and size of the trees by which the horizontal carvings are concealed, it is evident that a very considerable interval must have elapsed since the era of their production. The present native race can give no account of these remains."

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* Speaking of the paintings which are sometimes met with on the walls of caves in Western Australin, the Rev. C. G. Nicolay says:—"These are supposed to have been made and used by the Boolyas, but some are hunting pieces, and similar designs have been made on the walls of Rottnest Prison by the natives confined there." Notes on the Aborigines of Western Australia. Col. Ind. Exhib., 1886, p. 11. (8vo. London, 1886.)

† Aborigines of Victoria, 1878, II, f. 254 (to page p. 257).

‡ Centen. Mag. I, No. 1, p. 55.

§ Journ. Anthrop. Inst. Gt. Brit. and Ireland, 1880, IX, p. 82.

VII.—Explanation of the Carvings.

Dr. Carroll assigns to such carvings the importance of being totemic, or tribal emblems, or "symbolical of their tribal myths and laws," each animal or object representing a separate tribe. Thus, the speared kangaroo is the chief warrior; the shields (?) as the emblem of the beneficent spirit *Ndewa*, or *Ngungi*, and also of fire; the male figures represent Baiamai, "an ancestral spirit or God;"* the large fish, or shark is a god-emblem, and so on.

The myths and superstitions of the Australian Aborigines have been a source of speculation to all those who have written on them, and no doubt many of these hieroglyphics, if they may be so called, bore peculiar and special reference to some of these. They may even be totemic, although it must not be forgotten that such carvings seem to be more confined to the east-coastal region, within certain limits, than to other parts of Australia. If of this nature, and when found singly, acting as tribal boundary marks, as Dr. Carroll would seem to imply,† a serious difficulty presents itself in their indiscriminate distribution around the shores of Port Jackson; and the frequency of any particular totem would render the area occupied by its tribe in some cases remarkably limited. Were it not for this reason, and could the various totemic marks be assigned to their respective tribes, or families within a tribe, they would afford an admirable means of tracing the tribal geographical boundaries, and we might thus in time be able to lay down cartographically the distribution of many tribes, now only remembered in name.

It has also been suggested by Dr. Carroll that when occurring singly such figures may be regarded as tombstones. It is possible such may be the case; but from the fact that the Port Jackson blacks buried in their kitchen-middens and the hearths of their cave-shelters, and so far as known to the writer, not in the proximity of the carvings, this view would appear to be less likely.

I think it more than likely that this formed a portion of a *Bora*-ground, the spot set apart for the performance of the initiatory mysteries attending the entrance of youths into manhood's estate; and so apparently, does Dr. Carroll, from the context of his paper. Dr. J. Fraser‡ in his interesting account of the *Bora* in the Yūin Tribe, on the south-east coast, mentions that earth-modelled figures are used in addition to carved trees; it may be that in this particular case the stone-carvings take the place of the latter. Against this, however, is the irregular manner in which they are scattered; and on the general question the remarks of Mr. J. F. Mann. This author, in a very interesting paper, "Notes on the

* According to Dr. J. Fraser, B.A., the Kamilaroy Tribe use this name to signify the Creator or Supreme Being. Journ. R. Soc. N.S Wales for 1882 [1883], XVI, p. 207.

† Centen. Mag. I, No. 2, p. 91.

‡ Journ. R. Soc. N. S. Wales for 1885 [1886], XVI. p. 206.

Aborigines of Australia," wherein he figures a number of carvings, states—" No mystery whatever may be attached to these marks. I have seen a young man lying on rock, whilst others traced his outline, and then picked out the line with a tomahawk." *

Dr. Carroll traces the origin of the Australian blacks to a mixture of three Asiatic races—" the Papuan, the dwarf Asian negro or Nigrito, and the Indian Dravidian."† The Dravidian hunter, says Dr. Carroll, " brought with him his Indian dog—the Australian dingo." Now this opinion has a very strong bearing on the geological history of mankind on this Continent. So far, I believe, I am correct in stating, neither alluvial deposits, nor cave accumulations, with the one exception recorded by the late Mr. Krefft, have yielded the slightest trace not open to question, of man, or his works, in Australia. Cave earth, however, has revealed the presence of the Dingo, or rather the Warrigal, ‡ both in Victoria and New South Wales. Professor M'Coy has shown the presence of its remains in the Gisborne Cave, near Mount Macedon,§ and the late Mr. Gerard Krefft || in the Wellington bone caves. The latter remarks—" There can be no doubt, however, of the presence in this country of a dog during the post-pleiocene period; a few teeth were obtained at Wellington; they resemble the teeth of the common dingo of the present day." If, therefore, such remains are those of the native dog, truly fossil—and accepting Dr. Carroll's statement that this animal arrived with the Dravidian element of the present aboriginal race—it naturally throws the advent of the latter back to Post-Tertiary times. Conclusive geological confirmation of this is at present wanting. Both the late Mr. R. Brough Smyth¶ and the late Rev. P. MacPherson** call attention to the fact that even the stone implements of the aboriginal have not been found either in New South Wales or Victoria in any position, which could be described as other than forming a part of the present historical period. On the other hand, it will be of the utmost importance to receive confirmatory evidence of a paragraph in one of Mr. Krefft's papers, wherein he states:—" I have found the fractured crown of a *human molar* in the same matrix as *Diprotodon* and *Thylacoleo*, at Wellington, in this Colony," for on this, so far as we at present know, will hinge the yes, or no, of man's presence here in Post-Tertiary times.††

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* Proc. Geogr. Soc. Australasia, N.S.W. and Vict. Branches, 1885, I, p. 51.

† Centen. Mag. I, No. I, p. 54. This subject had previously been worked out generally in a very able manner by Dr. J. Fraser, B.A., in his paper "The Aborigines of New South Wales."—Journ. R. Soc. N. S. Wales for 1885 [1886], XVI, p. 193.

‡ Dingo is the term applied by the blacks to the white man's cur. The native dog is the Warrigal.

§ Melbourne Exhibition Essays, 1861, p. 163; Geol. Survey Vict. ¼ Sheet 7, N.W., *note*.

|| Australian Vertebrata, Resent and Fossil, 1871, p. 17.

¶ Aborigines of Victoria, 1878, I, p. 364.

** Journ. R. Soc. N. S. Wales for 1885 (1886), XIX, p. 117.

†† Geol. Mag., 1874, I, p. 46. (See a Paper by the Writer, read before the Linnean Society of N. S. Wales on 30th April, 1890.)

V.—Note on *Dromornis australis*, Owen: By R. ETHERIDGE, Junr., Palæontologist.

IN dealing with the history of this bird* I omitted to mention that the late Mr. Gerard Krefft, in a short paper entitled "Further Discovery of remains of a Great Extinct Wingless Bird," states that he "had already described it" (*i.e.* the femur from the Peak Downs) "in one of our local papers, and proposed for it the name of *Dinornis Owenii.*"† I am not acquainted with this description, but the medium of publication, even supposing the description to be a full one, forbids the recognition of the name.

Mr. Krefft also referred to bird bones which he had received from Mr. James T. Plunkett, on September 7th, 1873, found in the "Sandhole" Claim, Black Lead, Gulgong, at a depth of one hundred and sixty feet, consisting of "fragments of vertebræ of a bird rather stronger built than the emu, but not larger in size." These may be portions of the same species lately described by Mr. de Vis, as *Dromaius patricius.*

* Rec. Geol. Survey N. S. Wales, 1889, I., pt. 2, p. 126.
† Geol. Mag., 1874, I, p. 46, *note.*

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. II.] 1890. [Part 2.

VI.—The Raised-beaches of the Hunter River Delta, with Plate III; by T. W. EDGEWORTH DAVID, B.A., &c., Geological Surveyor, and R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate III.]

I.—*Introduction.*

IN the present paper it is our intention to describe the Raised-beaches of the Hunter River Delta, more particularly those around Maitland, but before so doing we wish to preface our remarks with a general account of what has been already written on the elevation of the eastern and portions of the southern coast of Australia since the close of the Tertiary Era.

II.—*Other instances of Raised-beaches.*

We have stated later our belief in these shell beds affording evidence of an elevation of the Hunter Estuary. Let us now inquire what further traces there are of similar deposits on other parts of the Australian Coast, north and south.

The late Prof. J. B. Jukes, describes small sandy flats existing at intervals along the north-east coast, wherever he landed during the surveying voyage of H.M.S. "Fly," between Cape Upstart and Sandy Cape. These flats consist of coral conglomerate, "several feet above the reach of any possible tide," * and strewn with pumice pebbles, but never extending more than fifteen feet above high-water mark. Again, at Lizard Island, pumice was found extending for one or two hundred yards back from the sea.† We cannot do better than quote his general

* Narrative of the Surveying Voyage of H.M.S. "Fly," 1847, I., p. 58.
† Ibid, p. 95.

remarks on this coral conglomerate, in the following words:—"It must either have been formed under water, in which case its existence as dry land proves elevation of the whole coast, or it must have been produced by the piling action of the surf heaping up successive accumulations of calcareous sand, which has subsequently compacted into rock. In the latter case, it never could have reached *a higher level* than it now has (a few feet above high-water mark), and its formation by this action must have required an immense period of time, during the whole of which *no depression can have taken place.* Upon all these flat spaces formed of this conglomerate, as well as upon all other flat land along the eastern and north-eastern coast of Australia, which is not more than ten feet above high-water mark, there is found an abundance of pumice pebbles . . . . They are never or very rarely seen on the present beach, or recently washed up, nor are they now found floating at sea. By whatever cause they were cast upon the land, their present position proves that the whole coast where they are found has been equally stationary, or equally affected by movements of elevation or depression since they were so cast . . . . That the advent of these pebbles is not a very recent event is proved by facts I observed on the north-east coast. I have picked up pumice pebbles, for instance, on sand and mud flats more than a mile from the sea. If those pebbles were hove up by breakers, there must have been a mile of addditional ground added to the flat since the time when they were so hove. If they were thrown on the land by a sudden wave of great magnitude, this evidence for lapse of time would fail, but that they were not so thrown is, I think, made clear, partly by their equal distribution over the flats, but more especially by their frequently occurring in considerable quantities embedded in the coral conglomerate of which many of the flats are composed. They are also found embedded in the coral rock of Raine's Inlet. Whatever age, therefore, may be given to the coral conglomerates must be extended to the pebbles. Altogether, the evidence derived from the existence of the coral conglomerates, and the presence of pumice pebbles, to a height of eight or ten feet above the highest possible tides, proves, to my mind, that for a very long period the whole eastern coast of Australia has either been quite stationary, or has been affected by slight movements of elevation."* Raised beach beds and pumice were observed by Jukes, at Wollongong, and the latter was known to him to occur at intervals along the coast-line for upwards of two thousand miles.†

The pumice question is again referred to by Jukes in his "Physical Structure of Australia,"‡ but it is to be regretted that the conclusion arrived at by such sound reasoning as the above quotation is abandoned, his mind being apparently influenced by Dr. Darwin's coral reef theory; he, however, remarks—"In the

* Narrative of the Surveying Voyage of the H.M.S. "Fly," 1847, I., p. 335.
† Ibid, p. 336.
‡ Page 34 (8vo., London, 1850.).

southern part of New South Wales, indeed, and in Tasmania, there are evidences of elevation of the land. . . . . in raised beaches and in beds and accumulations of sea shells beneath the present soil to very considerable altitudes."

On the Cape Upstart coral conglomerate we likewise have the benefit of Capt. J. Lort Stokes' opinion, who was also well acquainted with Darwin's views. He remarked,—"I will, myself, here adduce what may be deemed an important fact; and which, if allowed its due weight, will go far to weaken the arguments brought forward in favour of subsidence of the N.E. coast of Australia. I found a flat nearly a quarter of a mile broad, in a great sheltered cove, within the Cape, thickly strewn with dead coral and shells, forming, in fact, a perfect bed of them —a raised beach of twelve feet above high water-mark. On the sandy beach fronting it, also a few feet above high water-mark, was a concretion of sand and dead coral, forming a mass about fifty yards long. Fronting this for about the width of one hundred and fifty feet, was a wall of coral, with two feet of water on it, and immediately outside, five fathoms. . . . . Had it been on the seaward side of the cape, I might have been readier to imagine that it could have been thrown up by the sea in its ordinary action, or when suddenly disturbed by an earthquake wave, but, as the contrary is the case, it seemed impossible to come to any other conclusion than that an upheaval had taken place."*

Corroborative evidence is to be found in Dr. Alexander Rattray's remarks † on the Great Barrier Reef and the islands within it. He says,—"Equally interesting is the evidence that the north-east, if not the whole of the east coast of Australia, is slowly rising, to be found in the gradual shoaling of the channel between Hinchinbrook Island and the mainland (lat. 18½° S.), which is due, to all appearance, neither to silting up nor to the growth of coral . . . . in the shoaling of the inner barrier-reef route and the numerous openings through it, as well as the reef itself, which will one day be out of water, like Raine and other islands." He describes Raine Island as ten feet above high water-mark, and consisting of hard, compact, brecciated coral conglomerate. "It is evident that, though now permanently out of it, it must have been formed well under water, and have reached the surface at low water with the zoophytes which built it in full activity, when the greater part of the long reef now in full activity at the sea level at ebb, and of which it forms only a fractional part, was still many feet below. And now, when the latter has reached close to the surface at low water, the former projects twenty feet in the air."

The Rev. P. N. Wilton long ago stated that the pumice came ashore in the neighbourhood of Newcastle after south-east gales, and in its texture bore a striking resemblance to that abounding on White Island, a more or less active

* Discoveries in Australia, &c., 1846, I., p. 332.
† Notes on the Geology of the Cape York Peninsula, Australia.—*Quart. Journ. Geol. Soc.*, 1869, XXV, p.p. 302-304.

volcano to the north of the East Cape of the north island of New Zealand.* On this question the Rev. W. B. Clarke remarked,† on the authority of Dr. Dieffenbach, that the pumice could not have come from this locality, but on the contrary he considered it to be very old, "the *débris* of a source long ago erupted." He suggests one or other of the Pacific Islands, such as the Solomons, New Caledonia, Friendly, or Sandwich Islands, or a submarine volcano. Mr. Clarke traced this deposit of pumice in places from the Hunter River to Illawarra, on the north side of bays, such as Bondi Bay and Jervis Bay, but at Red Head, near Newcastle, the deposit lies above high-water mark. The source was believed by Mr. Clarke to be from the north, the pumice being caught by easterly winds and driven accross the current.

In another place he remarks,‡ "All along the coast from Torres Straits to Bass' Strait drift pumice may be found wherever there is a lodgment, generally in the north corner of the little shore bays. That this has gone on for ages is apparent, as in one part of the coast, north of Wollongong, there is an accumulation of water-worn pumice some distance from the shore, and beyond the reach of the present waves." Of raised-beaches proper, Mr. Clarke observed that they "occur at various heights on rocky projections of the coast, indicating elevation of the land, of which there is distinct evidence in the recent period, not only in Moreton Bay, but near Sydney, and thence to Bass' Strait; also on both sides of that strait, and as far as Adelaide and King George's Sound."

Equally important remarks were made by Prof. J. D. Dana when writing his Geological Report of the United States Exploring Expedition, under Commodore Charles Wilkes, U.S.N. He states that, "On the eastern coast there are occasional elevated beaches, or deposits of shells, and some appearance of terraces." Prof. Dana further describes a low ridge existing along the coast for most of the way between Bulli and Wollongong, about twenty to twenty-five feet above sea-level, consisting largely of shells, both broken and entire. This bank is at least ten feet above high-water mark, and is clearly regarded by the author as a raised-beach. He also considers that the Illawarra flats, from the foot of the coast range, have been but recently rescued, geologically speaking, from marine action.§

As regards the northern coast of the Continent, facts appear to be scanty, although Mr. Fitton gave|| a good deal of information on the calcareous shore breccias and sand-rocks of that region, which would seem to demonstrate a general upheaval of portions of the coast-line and adjacent regions.

* A Sketch of the Geology of six miles of the South-east Line of the Coast of Newcastle in Australia.—*Phil. Mag.*, 1832, I, p. 95.

† On the Occurrence of Atmospheric Deposits of Dust and Ashes, with Remarks on the Drift Pumice of the Coasts of New Holland.—*Tas. Journ. Nat. Sci.*, 1842, I., No. 5, p. 340.

‡ Sedimentary Formations of New South Wales, 3rd Ed., 1875, pp. 57 and 58; 4th Ed., 1878, pp. 107 and 108.

§ U.S. Exploring Exped., Vol. X, 1849, Geology, p. 353.

|| An Account of some Geological Specimens collected by Captain P. P. King, in his Survey of the Coasts of Australia, and by Robert Brown, Esq., on the Shores of the Gulf of Carpenteria, during the Voyage of Captain Flinders.—*P. P. King's Narrative of a Survey of the Inter-tropical and Western Coasts of Australia, 1818-1822*, Vol. II, 1827, *App.* c., *Par.* v., p. 566.

Turning more particularly to the south coast we have the late Messrs. Ludwig Becker and J. E. T. Wood's evidence. The first of these writers drew attention* to the rising of the shores of Hobson's Bay, Port Phillip, as shown by readings made by Mr. R. L. J. Ellery, of the self-registering tide gauge at Williamstown Observatory, and the appearance of new ground in the bay at points uninfluenced by the deposited matter of the Yarra River. The Rev. Mr. Woods, in his interesting work the "Geology of South Australia," † proves an upheaval to have taken place from King George's Sound to Melbourne by the alteration of coastal lakes from salt to fresh, and the occurrence of marine shells in their banks; the appearance of new reefs of rock along the coast-line, the alterations of soundings, and other features. On this point the first of these authors remarks that since the expedition of Flinders in 1802 a steady rise has been noticeable, for "the soundings of that navigator are rendered useless by the action of subterranean powers." Mr. Becker calculated the rise at about four inches a year.

Count de Strzelecki instances in his "Fourth Period" several cases of "elevated beaches," such as at Lake King, Gippsland; between Cape Liptrap and Portland Bay; Green Island, in Bass' Strait, &c.; but it is possible, and even probable, that these deposits have been relegated to other newer Tertiary formations, rather than retained as portions of those now under consideration.

The observations of the authors just quoted leave little doubt in our minds that a Post-Tertiary elevation of the eastern and southern coasts of Australia actually took place, and the Hunter Valley shell-beds, herein described, offer a strong confirmation of this view. It is also probable that this elevation is to some extent still going on.

Whilst on the subject of the shore pumice it will not be out of place to mention that Prof. A. Liversidge does not find it to actually agree in composition with that of the 1883 eruption of the volcano of Krakatoa,§ although there is a great resemblance. It is, however, stated by F. D. Bennett in his "Narrative of a Whaling Voyage round the Globe from the years 1830 to 1836, &c.,"‖ that in a strait between the Island of Wageeoo and the Yoel Group, Indian Archipelago, "vast quantities of pumice stone floating in small pieces rounded by attrition" were observed. "Some of them were black, others of an olive-gray colour. . . . Their origin is due to the volcanic islands of this Archipelago: the volcanic mountain of Ternate is often in action; and as late as the year 1836 South-Seamen cruising in the straits of Timor were compelled to keep their decks wet on account of the showers of hot ashes thrown upon them during a volcanic eruption on the Island

* Some Facts determining the Rate of the Upheaval of the South Coast of the Australian Continent.—*Trans. Phil. Inst. Vic.*, 1859, III, p. 7.
† Geological Observations in South Australia, 1862, p. 205.
‡ Phys. Descrip. N. S. Wales, &c., 1845, p. 143.
§ Journ. R. Soc. N. S. Wales for 1886 [1887], XX, p. 236.
‖ Vol. II, p. 67 (8vo. London, 1840.)

of Flores. Such collections of pumice stone on the surface of these seas are not uncommon, and are occasionally so great that ships have had their copper brightly polished by passing through them."

II. Raised-beaches of Maitland.

(A) Definition of terms:—The term "beach", as used by us in this paper, is applied to estuarine deposits which we believe to have been formed *in situ*, in an arm of the ocean, at or below high-water mark. The term "raised" obviously implies that subsequent to their formation they have been elevated more or less above the level of high tide.

(B) Localities:—I. Font Hill, near Farley, West Maitland. The first raised beach in this district, recognised as such, was discovered here by one of the authors in 1886, through information supplied by the late Mr. Peter Green, of Font Hill, several specimens of marine shells, evidently belonging to some comparatively recent geological formation, being found in the spoil-bank at the mouth of an old shaft near there. The shaft being full of water and closely timbered down to the bed rock, it was only by the help rendered by the members of the Maitland Scientific Society that the shell bed was at last reached, and a collection of its shells obtained, most of which are in the Society's Museum in West Maitland.

II. Largs, between East Maitland and Morpeth. Portion of a raised beach was discovered here by Mr. Geological Surveyor Stonier in 1887.

III. Race-course Paddock near East Maitland. A small outlier.

IV. Mr. Hyndes', Regent-street, Campbell's Hill, West Maitland. A small outlier discovered by Mr. J. Waterhouse, M.A., Inspector of Schools.

V. Knott's Well, Bolwarra, near West Maitland. A small outlier.

VI. West Maitland Water-works, Oakhampton Road, West Maitland. Information supplied by Messrs. Walsh and Nicholson, Engineers-in-Charge of the Water-works, shows that an ancient sea-beach exists here where the Oakhampton Road crosses the line of the supply pipe from the Hunter River.

Marine shells have also been met with in part of the same delta deposit in which the Maitland beaches occur, near Mr. Avard's house, at Thornton, and in the alluvial flats below Raymond Terrace. The levels of these latter shells deposits are not yet known.

(C) General Physical and Geological Features:—All the above localities are situated at or near the head of the delta of the Hunter. The district in which this delta lies may perhaps belong to that strip of the coastal area of New South Wales, which Mr. C. S. Wilkinson, F.G.S., has described as having been faulted down in an easterly direction probably during some portion of the Tertiary Era *

* Mineral Products of New South Wales—Government Printer, Sydney, 1880, p. 70.

This fault, or possibly sharp monoclinal fold, is strongly developed at Lapstone Hill at the first Zigzag near Penrith. It has a general northerly trend, and has thrown down the Lower Mezozoic strata on its eastern side approximately one thousand feet. It is to this dislocation that Mr. Wilkinson attributes the origin of the harbours of Port Jackson and Broken Bay, the faulting down of this area having allowed the waters of the Pacific to ascend some distance up the valleys of the Parramatta and the Hawkesbury Rivers, and so having converted them into estuaries. The boring operations in connection with the placing in position of the iron cylinders, on which the piers of the Hawkesbury Railway Bridge rest, afforded some slight confirmation of this theory. In several places the bores were carried to a depth of over one hundred and twenty feet below the present level of the Hawkesbury River in alluvial beds throughout, and in places at depths of as much as seventy feet below the bed of the river the trunks of large trees were found, bedded horizontally in the silt. This evidence is obviously not conclusive as to the lower alluvial beds here being of fluviatile rather than estuarine origin, as even now during heavy floods in the river, large trees are borne out into deep sea before they become water-logged and sink to the bottom. There is no evidence at present to show whether or not the depression of the coastal area resulting from the Lapstone Hill fault extended as far north as Maitland, as hitherto no unquestionably fluviatile remains have been met with in the deeper portions of the Hunter Delta, unless the thin beds of lignite passed through at Stockton near Newcastle, and in the bore near the old soap works at Long Bridge, West Maitland, are referable to deposits of this kind.

The Hunter Delta is bounded on all sides by low hills few of which exceed five hundred feet in height, composed chiefly of Permo-Carboniferous rocks amongst which those of sedimentary origin locally predominate, though considerable areas on the northern side of the delta are occupied by eruptive and tuffaceous rocks, some of which perhaps belong to the Carboniferous Period. A great unconformity separates the beds of the delta from those of the surrounding formations, the former being Tertiary or Post-Tertiary, while the latter are Permo-Carboniferous or Carboniferous. The delta at its seaward termination, has the shape of a rudely triangular area, the apex of which is prolonged further inland into a number of branches extending a considerable distance up the valleys of the Hunter, Williams, and Paterson Rivers. Along the coast it measures twenty miles in width in a N.E. direction from Newcastle to Port Stephens. Inland it has a general westerly trend following that of the valley of the Hunter River for about a similar distance. The total area is about two hundred square miles. The beds of which it is formed vary in total thickness from a few feet up to two hundred feet, the bottom of the beds where this maximum thickness is attained being about one hundred and eighty feet below sea-level. The surface of the delta is slightly conical, there being a general slope from its head at the

Falls, West Maitland, towards the ocean. The uniformity of this slope is broken at Maitland only by outlying high terraces of ancient flood loam capping The estuarine beds, and to the east of Sandgate and Raymond Terrace by dunes of sand. As the Hunter River is tidal from its mouth up to The Falls, a distance from the ocean—measured in a straight line—of about nineteen miles, it follows that the banks and adjoining flats which are only a few feet above the high-water level at Newcastle gradually increase in height westwards, until at West Maitland they are from thirty to forty feet above the level of high-water mark at Belmore Bridge.

The beds of which the delta is composed are capable of being divided into three different groups, the oldest being placed first:—

1. Sand-rock (half-consolidated sandstone.)

2. (*a*) Ancient estuarine deposits including the raised-beaches.

   (*b*) Ancient flood-loams capping the preceding, and considerably above the level of the highest known modern floods.

   (*c*) Ancient blown-sands perhaps the Æolian equivalents of the raised-beaches.

3. (*a*) Modern flood-loams.

   (*b*) Sand-dunes lately formed, or now in course of formation.

   (*c*) Peat beds forming in swamps on alluvials of delta, and more or less surrounded by the sand-dunes.

   (*d*) Shell-mounds formed by Aborigines.

1. Sand-rock is a fairly hard sandstone horizontally stratified, and varies in thickness from a few up to ten feet. It is developed chiefly on the down-throw side of faults, to the presence of which its preservation appears to be due. No fossils have been found in this formation, and it rests as a rule immediately on the Permo-Carboniferous rocks. Its relation to the raised-beaches is not clear, but it appears to antedate them. It is developed at Eagleton, Thornton, and at the Trigonometrical Station at East Maitland.

2. (*a*) Ancient estuarine deposits including the raised-beaches. By far the greater part of the Hunter delta is probably made up of these beds. They are composed chiefly of sandy clays, stiff bluish-grey clay, sand and gravel, with an occasional layer of lignite and peat. At the bores lately put down at Grahamstown, near Raymond Terrace, and Morna Point, near Port Stephens, these beds were proved to have a thickness of about

one hundred and eighty feet, with a capping of blown-sand about twenty to fifty feet thick. At the former bore (No. 2) marine gasteropodous shells were found in these beds within a few feet of the bed-rock, and at about one hundred and eighty feet below sea-level.

At the No. 1 bore at Grahamstown the following descending section was measured:—

ft.	in.	
73	0.	—Drift sand passing into bluish-grey sandy clay.
77	0.	—Sandy-clay, with a layer of pebbles separating it from the the Permo-Carboniferous bed-rock.
Total, 150	0	

In the same beds in a bore on Tilligerry Creek, a bed of peat, several feet thick, was penetrated at about ninety feet below sea-level.*

At the seventy-two-foot bore at the old Soap Factory, at the Long Bridge, West Maitland, alluvial deposits consisting of gravel, clay, and one thin band of lignite, and probably belonging to this group, were proved to extend to a depth of about thirty-six feet below high tide, and similar beds were proved to have at least as great a thickness at the bores put down before the erection of the flood gates at Wallis' Creek, Victoria Bridge, East Maitland.

(*b*) Ancient flood-loams capping the beds of the preceding group. These are developed chiefly near the head of the Hunter Delta, at West Maitland, and near Paterson. No fossils have as yet been found in them. Their thickness varies from twenty to forty feet, their upper portions being from twenty to thirty feet above the level of the highest recorded modern floods.

(γ) Ancient blown-sands. These are developed chiefly in the sheltered hollows of the Permo-Carboniferous rocks, near Maitland, and in some cases rest immediately on the flood loams. Their thickness varies from a few feet up to ten feet.

3. (*a*.) Modern flood-loams. To this group belong all the black soil areas, inundated by floods, and constituting some of the richest farming land in New South Wales. These beds consist of black loamy-clay, sand and river gravel, and attain a maximum elevation of about thirty feet above high water, there being a surface slope of about eighteen feet in these beds between West Maitland and Hinton, a distance of five and a-half miles. Thickness up to forty feet.

* This information was supplied us by Mr. D. Watson, of Waratah, one of the holders of the ground upon which this bore was put down at Bank's, on Tilligerry Creek.

(β) Sand-dunes. These are not developed in the neighbourhood of the raised-beaches, and appear to be of later date. They cover the eastern half of the Hunter Delta, between Sandgate and Raymond Terrace, and the ocean to a depth of from a few feet to over fifty feet. The greater portion of this deposit is not drifting now, its surface having become consolidated by the growth of vegetation, many of the trees being probably one hundred years old. Drifting is, at present, confined to a narrow fringe of sand about half a mile wide in places along the coast, between Newcastle and Port Stephens.

(γ) Peat beds formed in swamps occur chiefly in the hollows of the fluviatile beds belonging to the recent flood-loams, or in those of the sand-dune deposit. Small trenches dug by the Aborigines for catching eels are observable in places on the surface of these deposits, especially at the narrow necks by which one swamp is united with another.

(δ) Shell-mounds formed by the Aborigines. These are associated with the sand-dunes between Newcastle and Port Stephens, and are also observable around the shores of Port Stephens, though the largest of them have been destroyed for lime-burning purposes. These shell-mounds at Port Stephens are very similar to those described in the present number of the Records, by our colleague, Mr. Anderson, as occurring at Panbula, and elsewhere along the southern coast of New South Wales.

(D.) Details of the Maitland Raised-beaches. At Largs the following descending section was measured by the authors:—

ft.	in.	
20	0.	—Ancient flood-loam, a dark grey stiff clay.
0	6.	—Loamy-sand with marine shells.
0	9.	—Rusty-brown sand crowded with marine shells.
0	8.	—Ditto with shells tolerably plentiful.
3	0.	—Grey sand without shells.

The flood of 1857 was at this spot 16·66 feet above high water, and the great flood of May, 1890, which rose six feet six inches above the top of this raised beach, was probably here at least eighteen feet above high water, in which case the top of the shell bed would be at least eleven and a-half feet above the same. Aneroid levels make it fifteen feet above high water. The relation of the level of this shell bed to that of the great flood, and to sea level at high water is shown on the upper section of Pl. III.

At Knott's Well, near Bolwarra (See lower section on Pl. III), the following is stated to be the descending section:—

ft.	in.	
17	0.	—Blue clay.
1	0.	—Black sand with fragments of marine shells.
0	3.	—Sand with abundant marine shells.
8	0.	—Blue clay.
2	3.	—Sand, without shells.
Total... 28	6	

The great flood of May, 1890, was about four feet above the top of this well, and is stated to have been here about twenty-nine feet above high water, in which case the top of the shell bed must be about eight feet above high water, a level confirmed by aneroid measurements.

At Font Hill the shell bed was sixteen inches thick, the top of the bed being ten feet seven inches below the surface of the ground. The great flood was here twelve feet above the top of the shell bed. The mean of several aneroid measurements makes the top of this bed about eleven feet above high water. At the Race-course Paddock, near East Maitland, where the back road to Morpeth approaches the culvert from the south along the eastern boundary of the paddock, the following descending section was measured by one of the authors:—

ft.	in.	
0	6.	—Black clay, with a few marine shells.
0	6.	—Bluish and yellowish-gray clay, with a few marine shells.
1	6.	—Do. crowded with marine shells, *Scapharca gubernaculum* and *Mytilus Menkeanus* largely predominating.
0	6.	—Do with a few shells.
Total... 2	6	

The level of the top of this shell-bed is from eight to ten feet above high water. It has somewhat the appearance of a Kitchen-midden, but no burnt shells were detected, nor any certain indication of the shells having been gathered together by the agency of the Aborigines.

At Mr. Hyndes' the top of the shell-bed is at least six feet, probably as much as ten feet above high water. A star-fish was found here, associated with shells similar to those at Font Hill.

At the tunnel through which the suction pipe is carried from the Hunter River to the West Maitland Water-works, the top of the shell-bed is about twenty-eight feet below the surface of the alluvial, and about six or seven feet above high water.

(E.) Organic Remains.—The following is a list of the Organic Remains which have been so far determined from the Raised-beach Beds around Maitland:—

Name of species.	Race-course Paddock.	Hunter River at Largs.	Font Hill.
Ostrea Angasi, *Sby.*	m.c.	m.c.	m.c.
Ostrea subtrigona, *Sby.*	v.c.	r.	r.
Pecten Strangei, *Reeve*	—	v.r.	—
Pecten asperrimus, *Lamk.*	—	r.	—
5. Pecten tegula, *Wood*	—	m.r.	r.
Mytilus hirsutus, *Lamk.*	—	c.	? m.r.
Mytilus Menkeanus, *Reeve*, var.	v.c.	—	—
Scapharca gubernaculum, *Reeve*	v.c.	v.c.	r.
Chama spinosa, *Brod.*	m.r.	—	—
10. Tellinella deltoidalis, *Lamk.*	—	r.	—
Corbula scaphoides, *Hindes*	m.c.	c.	—
Spisula cretacea, *Angas*	—	v.c.	—
Tapes turgida, *Lamk.*	—	v.r.	—
Chione isabella, *Gray*	—	v.r.	—
15. Chione lamellata, *Lamk.*	—	v.r.	—
Dosinia sculpta, *Hanley*	—	v.r.	—
Venus (Temoclea), sp.	r.	m.r.	—
Clementia papyracea, *Gray*	—	v.r.	—
Fusus Hanleyi, *Angas*	—	r.	—
20. Nassa livida, *Gray*	—	m.r.	—
Nassa Jonasi, *Dunker*	—	c.	—
Natica conica, *Lamk.*	—	m r.	—
Natica plumbea, *Lamk.*	—	c.	—
Monilea lentiginosa, *A. Adams*	—	v.c.	—
25. Calliostoma decorata, *Phil.*	r.	v.c.	—
Enchelus atratus, *Gmelin*	—	r.	—
Triton costata, *Born*	—	v.r.	—
Triton pilæris, *Lamk.*	—	v.r.	—
29. Risella lutea, *Lamk.*	r.	r.	—
Lampania australis, *Q. & G.*	r.	r.	—
Potamides ebeninus, *Lamk.*	m.r.	m.r.	—
Trochocochlea multicarinata, *Chenu*	r.	—	—
33. Balanus trigonus, *Darwin*	—	r.	—

r = rare; m.r. = moderately rare; v.r. = very rare; c. = common; m.c. = moderately common; v.c. = very common. These terms simply express the relative degree of occurrence as estimated from the specimens we have seen.

We have had the advantage of studying three collections—a small and original set obtained by Mr. J. Waterhouse, M.A., Inspector of Schools*; another small collection lent by the Maitland Scientific Society; and the much larger series obtained officially under the direction of one of us. The second series was named by Mr. John Brazier, C.M.Z.S., and we are indebted to his intimate knowledge of Australian shells for assistance in the identification of the remainder. The first collection made by Mr. Waterhouse was of particular interest, containing, as it did, some species not met with in either of the others.

It will be at once apparent that the Largs bed is by far the most prolific, with thirty certain, out of the full number of thirty-three species, the absentees being *Mytilus Menkeanus*, *Chama spinosa*, *Trochocochlea multicarinata*. Three species on

* Ann. Report Dept. Mines N. S. Wales for 1889 [1890], p. 237

the other hand are exceedingly common at Largs, viz., *Scapharca gubernaculum*,* *Spisula cretacea*, and *Calliostoma decorata*. Special attention must be called to the occurrence in this bed of *Pecten Strangei*, *Natica livida*, and *Enchelus atratus*, neither of which are now met with on the New South Wales coast. The former species, of which two specimens were obtained, occurs on the north-east coast of the Continent, and throughout Torres Straits. *N. livida* if found from Moreton Bay round to West Australia; and *E. atratus* is met with in Torres Straits, and around New Caledonia, and the Philippine Islands.

The Race-course Paddock deposit is peculiar from the abundance of *Ostrea subtrigona*, *Mytilus Menkeanus*, *Scapharca gubernaculum*, and *Corbula scaphoides*. The second of these shells is perhaps the most remarkable in the collection, both on account of the numbers in which it occurs, and the fact that it also is not a New South Wales species, but occurs on the coast of South Australia. We were, with Mr. Brazier, mutually so struck with the large size and abundance of *Mytilus Menkeanus*, that a specimen was forwarded to Professor Ralph Tate, F.L.S,, of Adelaide University, for his opinion as to its correct identification. He considers it a rostrate variety of this species. The average size of South Australian examples is from one and a half to two inches in length, but at East Maitland it attains to a length of no less than six and a half inches, by three in breadth.

That a shell otherwise known to occur in South Australian waters, and three others, *Natica livida*, *Enchelus atratus*, and *Pecten Strangei*, elsewhere found in warmer seas, should occur in these Post-Tertiary beds, without inhabitating the coast of New South Wales, is a remarkable fact, and affords an opening for much speculation.

The fauna is essentially a littoral one, and in some respects estuarine also. For instance, *Spisula cretacea*, *Scapharca gubernaculum*, and *Potamides ebeninus*, specially come under the last category, two *S. cretacea*, and *S. gubernaculum* being very plentiful.

Evidence also exists that rather similar raised beach beds occur in Moreton Bay. Mr. R. L. Jack, Government Geologist of Queensland, has sent to one of us fossils from Child's Vineyard, corresponding closely with some of those mentioned above, such as—

Ostrea pestgiris, *Hanley*.
Anomalocardia trapezia, *Desh.*
Potamides ebeninus, *Lamk.*
Natica plumbea, *Lamk.*

The presence of an exotic species in our Post-Tertiary deposits is, however, not unknown, Mr. C. S. Wilkinson having exhibited at a meeting of the Linnean Society of New South Wales, held on 27th May, 1885, † a specimen of *Siphonalia*

* Great care is required in determining this species, as apart from *Anomalocardia trapezia*, which it much resembles.

† Abstract Proc. Linn. Soc. N. S. Wales, 27th May, 1885, p.v.; Proc. *ibid*, 1885, X, Pt. 2, p. 245.

maxima, Tryon, from the estuarine deposits sunk through at the Stockton, Bullock Island, and Wickham Coal Pits, Newcastle. This univalve was previously known only from the Tasmanian and Victorian coasts, and has not, so far, been observed on the shores of New South Wales by our closest observer, Mr. J. Brazier.

(F.) Agents.—The agents which are now making and modifying this Hunter Delta, are chiefly the fresh waters of the Hunter River, and its tributaries, the Paterson and Williams Rivers—wind, tide, and ocean currents.

The Hunter River and its tributary the Goulburn River together drain an area of 7,320 square miles, the average rainfall over the greater part of it being about fifty inches. During floods, as much as five-sixths of the rainfall for a month are computed to be discharged by the river at the rate of 130,000 cubic feet per second at the head of the delta, at Oakhampton. *

The total amount of water passing over the delta, during a great flood, such as that of 1857, is estimated by Mr. E. O. Moriarty, C.E., late Chief Engineer for Harbours and Rivers, to be 88,000 millions of cubic feet.

The quantity of silt brought down by such a vast body of water is necessarily considerable, and the greater part of it is deposited at the upper end of the cone of the delta, near West Maitland, where the river becomes tidal; the fall of its channel for the previous forty-nine miles from Singleton downwards having been at the rate of 2,088 feet per mile.

Sufficient data are not yet available for forming even an approximate calculation of the rate of deposition of this silt. The tide ascends from the present mouth of the Hunter at Newcastle, for a distance of about forty-nine miles measured along the winding course of the river and about nineteen miles in a direct line to the Falls above the Belmore Bridge at West Maitland.

At Morpeth the tidal wave seems to have been lessened somewhat by friction as the level of high-water there is stated† to be 1.07 feet below that of high-water at Newcastle. It is improbable therefore that the tidal wave, which travelled up the estuary now occupied by the Hunter Delta, was higher than the tide on the coast, the tides of the raised-beach period being assumed to have risen to the same height on the coasts as modern tides. The fact, however, must be borne in mind that in estuaries such as Lake Macquarie near Newcastle, which communicates by only very narrow outlets with the ocean, and which receive a considerable amount of fresh water drainage, the permanent level of the surface of the water is about that of high tide. As, however, it has been assumed, when calculating the levels given in this paper, that the top of the Maitland Raised-beaches represents the former limit of high tide, the relative levels of these beaches, with regard to the present ocean, would still be the same, even supposing that the sea water in the ancient estuary of the Hunter remained permanently at high tide level.

* Floods in the Hunter. Report of Commission, &c., p. 10 and 101. BY AUTHORITY, Sydney, 1870.
† *Loc. cit.*, p. 121.

The tide exercises very little scouring action on the bed of the river, but on the seaward slope of the delta assisted by ocean currents it considerably adds to the delta by carrying large quantities of sand from other parts of the coast and depositing them along the shore between Newcastle and Port Stephens, whence they are blown inland by south-easterly winds towards Raymond Terrace. In view of the loading which the toe of the delta has undergone from this cause, it seems strange that this portion of it has not somewhat subsided.

(G.) Summary.—From the facts above quoted, the history of the formation of the Hunter Delta would seem to have been somewhat as follows :—

At a time, belonging probably to some part of the Tertiary Era, a large estuary, which may have originated partly through the Lapstone Hill fault, occupied the site of the present delta, extending inland from Port Stephens and Newcastle to West Maitland. The Hunter River emptied into this estuary and commenced to form its delta at Oakhampton, the Paterson River did the same at Paterson, and the Williams River at Seaham, the deltas, as usual, formed in the shape of flattened cones, the apex of each pointing up their respective valleys. The estuarine beds were by this process gradually buried under a thickness of from twenty to forty feet of fluviatile material, and ultimately the deltas of the Paterson and Williams become confluent with that of the Hunter, reducing the two first rivers to the positions of tributaries of the last mentioned river.

Subsequently there commenced a gradual elevation of probably the whole delta, in which movement the greater part of the east Australian coast appears to have participated.

This elevation would be most apparent at the upper ends of the delta cones, as these would be not only the highest, but also the oldest portions of the delta, so that they would show the accumulated results of an elevation, which may have been in progress for centuries. On the other hand the beds of the delta nearer the ocean, either from being newer and so having had a smaller share of the elevation, or from having been submerged to some depth below sea-level at the time when the elevation commenced, would be much less likely to show evidence of having undergone a similar movement.

The gradual elevation of the delta compelled the Hunter River and its tributaries to continually deepen their channels, in order to accommodate themselves to the alteration in the level of the land, and so the ancient estuarine beds and their capping of flood-loam near Maitland were constantly being eroded, the redistributed material derived from them contributing to form the present rich alluvial flats within reach of modern floods. The drifting of the sand-dunes inland from the coast, which has had the effect of raising the eastern portion of the delta above sea-level, may have commenced soon after the silting-up of the estuary between Maitland and Raymond Terrace; but the authors believe it to have belonged to a

time much later than that, when the raised beaches were being formed. No fragments of pumice have ever been observed in any of the Maitland raised-beaches, nor any traces of man.

(H.) Age.—As regards the probable age of these raised-beaches, although, of course, it cannot be calculated absolutely, some idea as to the necessity for admitting that it must have heen considerable, may be formed from the following proposition:—

The depth of the estuary before the fluviatile deposits commenced to form, being assumed to be thirty feet below the present level of high tide, the highest alluvial terrace being about fifty feet above high-water; time must be allowed in the first case for the accumulation of a total thickness of eighty feet of sediments, which at an assumed rate of deposition of one inch per year, would take nine hundred to one thousand years to form, and probably, at least an equal amount of time must have been occupied in the subsequent erosion of these sediments to a depth of about seventy feet, this work being accomplished partly by the river gradually altering its course so as to undercut the banks of the older river terraces, and partly of fresh-water floods.

Far stronger evidence, however, of the extent of this time is afforded by the changes which have taken place in the distribution of the estuarine molluscan fauna of the east Australian coast. Subsequent to the formation of the Maitland Raised-beaches, as explained in that portion of this paper which treats of their organic contents.

VII.—Notes on the Shell-heaps, or Kitchen-middens accumulated by the Aborigines of the Southern Coastal District; by WILLIAM ANDERSON, Geological Surveyor.

[Plates IV—V.]

THE district in question embraces the low-lying coastal area east of the Monaro Tableland, between Moruya and the Victorian border. Its coast line is indented by numerous estuaries and salt-water lakes, some of which are of considerable extent, and a few tidal. The seaward outlets of many of them are almost always closed, because of the banking-up of the sand by the action of the waves outside. After heavy rains, however, these sandy obstructions are generally washed away by the large bodies of fresh water which accumulate in the lakes during their passage to the sea.

The littoral portion of this part of the country seems from all accounts to have been permanently inhabited by certain tribes of Aborigines, who occupied specialised areas in the district. Little or no information has been put on record, relative to the manners and customs of these coastal tribes. As in other parts of the Colony, they had particular localities in which they performed certain rites and ceremonies, and in which they buried their dead. One position, on an island near the mouth of the Bodalla River, is known as having been used, even up to very recent times, as a burial-place of the local tribe. Relics of these coastal tribes, which are now nearly extinct (certainly so, as a pure race), are frequently met with over the whole district. These consist of stone weapons and implements, which are often ploughed up in the fields by the settlers; skeletons laid bare by the action of the sea and creeks; and artificial accumulations, such as the shell heaps or "Kitchen-middens," which occur so plentifully along the shores of the salt-water lakes. Relics of a more perishable nature, such as the various wooden implements and weapons used by the aborigines, including the boomerang, waddy, &c., and the grass-tree spears, tipped with a short length of hardwood, or barbed with sharp fragments of shells, are rarely met with in any of the recent deposits. The remains of canoes formed of a wide strip of bark have, however, occasionally been exposed on the beach. The two ends of the strip of bark, after having been made pliable by heat, were caught up in plaits, which were held in position by a short wooden pin inserted through them, and permanently fixed by a mass of dried grass-tree gum.

The shell-heaps or "Kitchen-middens," have a wide distribution along the shore-lines of the southern part of the coast. They are, however, chiefly confined to the shores of the innumerable estuaries and salt-water lakes which occur so frequently along the coast, many of which possess a large superficial area, and extend for miles inland. There is hardly one of these coastal indentations whose shores are not studded with shell-heaps, which are now, generally covered with vegetation, some of the trees growing upon them being of considerable size. As a rule the shore-lines are very irregular, consisting of deep bays, sandy spits and rocky promontories. On the shores of the bays, shell-heaps do occur, but they are usually isolated and rare, while in the two latter positions they are exceedingly numerous, individual heaps attaining considerable lateral extent. In every position they are in close relation to high-water mark.

As might be expected the shell-heaps do not always possess a common distinctive form, nor do they occur in positions which were especially selected for their adaptability, except in so far as the contour of the immediate shore-line was favourable for camping; although from the frequency of their occurrence on the promontories and spits, it would appear as if those positions were often chosen in preference to the more extended shore-lines of the bays, because of their proximity to the habitat of the molluscs which occur more abundantly off these points.

Near their extremities, most of the promontories and spits are very narrow, and of no great height above tide-marks and wherever they have been used by the Aborigines as camping grounds, their whole surfaces are now covered with empty shells, to a variable depth, in places, from a few inches, to four or five feet. On the rocky points the accumulations of shells take no definite shape, being promiscuously scattered over the surface, but on the sandy spits they occur in distinct heaps, sometimes nearly circular in horizontal outline, and often forming long mounds, having a somewhat oval base. Where they occur on the shores of the bays, the heaps are usually flattened, and the shells are more scattered, but this feature may perhaps be due to the effects of denudation subsequent to their formation. They always occur above ordinary high-water mark, although many of them have suffered on their seaward aspects from the denuding action of the high spring tides. Their extent and form seem to have largely depended on the configuration of the shore-line upon which they rested. Where the latter rises steeply and sharply from high-tide mark, the shell heaps upon it do not take the form of mounds, but the whole slope is covered with shells to a variable depth, and sometimes as high as thirty feet up the slope. Wherever the shore-line is flat or only gently sloping, the heaps have a distinctly mound-like shape, but vary greatly in length and height. Their relative size has depended chiefly upon the duration and frequency of the visits, paid by the Aborigines to the individual heaps.

Besides the empty shells, of which the heaps chiefly consist, distinct layers of wood ashes, which vary greatly in thickness and lateral extent, occur distributed through them. They usually form roughly circular patches varying from a few inches up to a foot in thickness. They generally occupy the centres of the more or less circularly-formed heaps of small size, and it would appear from their presence below the centres of such heaps, that the latter had originated around camp fires. In the larger oval mounds, and in those positions where the shells occur scattered over a slope, there are quite a number of distinct ash-layers, of varying thicknesses, and occupying, in relation to each other, different horizontal positions in the heap, although in many cases a section of one of the larger heaps generally shows a series of ash-layers one over the other alternating with layers of shells. These series of ash-layers probably represent distinct periods of visitation, and where they individually attain any great thickness, represent visits of considerable duration, for it is a well-known fact that the Aborigines were never in the habit of making fires of any size, and it would necessarily take a lengthened period for an ash-layer a foot thick to accumulate from these small fires. The presence of the ash-layers to a certain extent, gives an appearance of local stratification to the heaps. The different horizontal positions in which many of them are met with, indicate, that although, upon their return to the heaps accumulated on former visits, the Aborigines

sometimes made the fire directly over the old fire-place, still they indifferently placed it on other portions of the heap. The shells upon which the ash-layers immediately rested were in all cases slightly burnt, but this was the only position in which burnt shells were observed to occur. It is, therefore, I think most likely that the edible parts of the molluscs were eaten in a raw state, although it is somewhat difficult to imagine how they were able to extract the soft parts from the numerous large Gasteropods whose shells are so plentiful in the heaps, unless the shells were first heated in the fire, of which however there is no evidence. Some of the larger univalve shells have evidently been broken during the accumulation of the heaps, although the major portion of them are whole, and I think, it is evident from this that these shells were broken for the purpose of extracting the edible part. Many of them, however, were no doubt brought to the camp for the sake of the edible oysters adhering to their outer surfaces. Although the individual shells always lie promiscuously, in relation to each other, there are often local layers which consist almost entirely of specimens of one genus. For instance, it is not at all uncommon to find a layer chiefly consisting of the shells of *Scapharca gubernaculum* in the midst of a thick layer of oyster shells. All the heaps have much the same composition, except that some of them possess certain genera of shells in greater abundance than others. This is no doubt largely due to the comparatively greater abundance of the former genera near the spot where the heaps happen to have been accumulated.

There are only two positions in which I have yet had an opportunity of examining these shell-heaps minutely, on the shores of the estuary of the Wagonga River, which forms the boundary between the Parishes of Wagonga and Noorooma, County of Dampier; and on the Panbula River, between the Parishes of Yowaka and Panbula, County of Auckland. In the former position, on the Wagonga River, with the assistance of Mr. Watson, Schoolmaster at Punkally, two of these heaps were excavated, while a number of the others, which occur on its shores, were partially opened up. Pl. V. shows the positions of the various shell-heaps on Wagonga River, and Pl. IV. those on the Panbula River below the lake.

Wagonga River.—The first heap that was opened was situated on the south bank of the river near the extreme end of Shell Point, the western promontory of Foster's Bay, about a mile from the point where the estuary enters the sea. The name of the promontory is due to the presence of the large quantities of shells which form the various heaps. The largest and best defined heap occurred on the extreme end of the sandy spit which tails off the promontory, and through the centre of this a wide trench was cut. The longer diameter of the heap was in line with the axis of the sand-spit. At the point of the spit the shells, at the lower seaward edge, reached high-water mark, and at these places the heap had been somewhat denuded by the waves. The centre of the heap was five feet

in depth, and in cutting through it the section exposed presented three layers of ashes superposed, with layers of shells between. The following is a section giving the approximate thicknesses and mode of occurrence of the various layers:—

	ft.	in.
Surface Soil	0	2
Shells, chiefly *Ostrea Scapharca*, &c.	0	6
Ash layer	1	0
Shells, chiefly *Ostrea*, *Scapharca*, &c.	1	0
Ash layer	0	6
Shells, chiefly *Ostrea*, *Scapharca*, &c.	1	6
Ash layer	0	4
Total thickness... ...	5	0

Besides these centrally placed ash-layers, others were met with in different parts of the heap. The shells immediately below the layers of ashes were always found to be burnt, but those above were never so affected. The most common genera represented in this heap were the species of *Ostrea*, *Scapharca* with *Anomalocardia* and *Potamides*, most of the others being comparatively rare in their occurrence.

The heap contained no vertebrate remains of any great importance. The latter consisted chiefly of fish bones, and in a few places thin layers of fish scales, the result no doubt of the decomposition of pieces of fish skin. A few animal bones also occurred but these were chiefly the remains of small animals, none of them being identifiable. No human remains, nor undoubted implements, nor weapons were met with.

About a quarter of a mile up the Wagonga River, above its junction with Punkally Creek, another large heap was excavated on its right bank. In its general characters it closely resembled that just described at Shell Point. There were, however, a less number of oyster shells and a greater number of specimens of *Scapharca gubernaculum*, the latter form being most abundant in the upper portion of the heap, while the lower part consisted chiefly of species of *Ostrea*, specimens of *Potamides ebeninus* being abundantly distributed throughout. Superficially the heap was very extensive, and over three feet in its deepest part, supporting on its surface trees over a foot in diameter. The great number of ash-layers, some of them of considerable thickness and extent, and the decomposed state of the shells in the lower parts of the heap, would indicate that it was, comparatively speaking, of considerable age. It rested on the sandy beach, and its lower edges were washed by the high tides. In this heap,

almost the entire skeleton of a small dog, or dingo was obtained. It occurred at the bottom of the centre of the heap, resting on its left side, on the original surface of the shore on which the heap was accumulated. The skull was complete, and most of the bones of the four limbs were present with a few of the cervical vertebræ, a fractured scapula, and a few fragments of the pelvis. The ribs, and nearly the whole of the vertebral column and pelvis were wanting. Such bones as remained were whole, but so soft and decomposed, that the skull fell to pieces when it was being taken out. The teeth were all present and perfectly preserved. A few rudely shaped fragments of rock, having somewhat sharpened edges, which were, however, not artificially produced, were also met with at various depths. These may possibly have been used as shell-openers. They were generally discoloured, being usually found in close relation to the the ash-layers. Fish bones, jaws and scales, together with the bones of small vertebrates and birds occurred in abundance. Most of the other heaps existing on this river were examined, but not thoroughly excavated. Those occurring on the sandy spit, at the mouth of the Punkally Creek differed from the others by being almost entirely composed of the shells of *Scapharca gubernaculum* and *Potamides ebeninus*, the shells of *Ostrea* being of very rare occurrence.

Panbula River.—The shell-heaps on this river occur chiefly along the shores between Panbula Lake and the sea, although there were one or two heaps on the river banks above the lake, between the latter and the town. I had not an opportunity of examining the shores of the lake itself, where it is probable that numbers exist. Between the lake and the sea they chiefly occur as scattered patches of shells, few having a mound-like shape. This is due to the configuration of the shores which rise steeply on both sides from the river, allowing of the presence of but few bays or flat sandy spits. In appearance, the heaps seem to be very large, but on closer inspection they are found to be of no great depth, although the shells are widely scattered over a large area of the steep banks, even in some cases to a height of over thirty feet. The chief genera represented here are specimens of *Ostrea*, *Mytilus*, *Scapharca*, and *Potamides*. The two species of *Mytilus* are of comparatively rare occurrence in the heaps on Wagonga River. The only vertebrate remains which were obtained, were fish bones and scales, with a few bones of small vertebrates, although I was told that while some of the neighbouring farmers were burning the shells for lime, they repeatedly came upon the remains of human skeletons, and tomahawks, which, however, do not seem to have been preserved.

A list is given below of the species of shells which were obtained during our excavations of the heaps on Wagonga and Panbula Rivers respectively. The specimens were identified by Mr. R. Etheridge, junr., Palæontologist to the Geological Survey, with the kind assistance of Mr. John Brazier, C.M.Z.S.

Name of Species.	Shell Point, Foster's Bay, Wagonga River	South side Panbula River.
Ostrea Angasi, *Sby.*	v.c.	v.c.
Ostrea cuculata, *Born.*	v.c.	v.c.
Ostrea mytiloides, *Lamk.*	m.r.	m.r.
Janira funatus, *Reeve*	r.	r.
5. Pecten tegula, *Wood*	r.	—
Mytilus hirsutus, *Lamk.*	m.r.	m.c.
Mytilus Dunkeri, *Angas*	m.r.	m.c.
Chamostrea albida, *Lamk.*	r.	r.
Scapharca gubernaculum, *Reeve*	v.c.	c.
10. Anomalocardia trapezia, *Desh*	v.c.	—
Rupellaria crenata, *Lamk.*	r.	r.
Chione (Chamelæa) strigosa, *Lamk.*	—	r.
Fusus Hanleyi, *Angas*	r.	r.
Triton Spengleri, *Chem.*	m.c.	m.c.
15. Ranella leucostoma, *Lamk.*	m.r.	m.r.
Natica melastoma, *Sw.*	m.r.	—
Natica plumbea, *Lamk.*	—	m.r.
Natica melanotragus, *Smith*	—	m.r.
Trochocochlea zebra, *Menke.*	m.r.	m.r.
20. Trochocochlea tricarinata, *Chem.*	m.r.	—
Lunella undulata, *Martin*	m.r.	m.r.
Lampania australis, *Q. and G.*	r.	—
Risella nana, *Lamk.*	r.	r.
Calliostoma decorata *Phil.*	m.r.	m.c.
25. Potamides ebeninus, *Lamk.*	v.c.	v.c.
Patella tramoserica, *Martin*	—	m.r.
Patella aculeata, *Reeve*	—	m.r.
Ophicardelus australis, *Q. and G.*	—	r.
Polytropa succincta, *Martin*	—	r.
30. Acmæa alticostata, *Angas*	—	r.
Siphonalia dilatata, *Q. and G.*	—	v.r.
Helix (Discus) funerea, *Cox*	—	v.r.
Total	22	27

v. c. = very common ; c. = common ; m. c. = moderately common ; m. r. = moderately rare ; r. = rare ; v. r. very rare.

Mr. Etheridge supplements this list with the following remarks upon a rare species of Gasteropod which occurred in one of the heaps on Panbula River. "The species detailed in the above lists are such as may still be met with on the coast of New South Wales generally, with the exception of *Siphonalia dilatata*, Q. and G. This is a Tasmanian species, and also occurs on the Victorian coast, Mr. J. Brazier having received an example from Corner Inlet. This is the first record, within my knowledge, of the discovery in a Kitchen-midden of a shell not otherwise known on the New South Wales coast."

In most of the heaps examined, the genus which occurred most frequently comprised the various species of *Ostrea*, and of these, the large mud oyster (*Ostrea cuculata*) was by far the most common. Next in abundance were specimens of *Scapharca*

gubernaculum, *Anomalocardia trapezia*, and the Gasteropod *Potamides ebeninus*. The heaps occurring on the sandy spit at the mouth of Punkally Creek, however, consisted chiefly of the shells of *Scapharca* and *Anomalocardia*, with *Potamides*, the oyster being by no means common. It was rare indeed to find any specimens of the Gasteropod mentioned above in a fractured or broken condition. In comparing the list of species from the two localities, it will be seen that of the total thirty-two, seventeen were common to both, and these consist chiefly of the larger edible forms. Ten species which occurred in the Panbula heaps were not, so far as my examination went, represented in those of Wagonga River, while the other five species, although present in the latter heaps were absent from the former locality. Many of those species which were not common to both localities, are chiefly small forms which might not have been much sought after as food. The abundance of the two genera *Scapharca* and *Anomalocardia*, in the heaps at the mouth of Punkally Creek, as compared with the rare occurrence of the genus *Ostrea*, which form such a large portion of the other heaps on Wagonga River, may be explained by the fact that the tide does not affect the waters of the Punkally Creek to such an extent as it does the Wagonga River, and consequently the waters of the former creek are a great deal less salt than is the case in the river. The result of this is that the more estuarine forms *Scapharca* and *Anomalocardia* were more abundant off the spit at the mouth of the creek than the oysters were (such is now the case), and the Aborigines who were in the habit of camping there, took the molluscs which they could the more readily obtain.

From various sources I have heard it stated that human remains (skulls and complete skeletons), tomahawks, and other relics of the Aborigines, have from time to time been dug out of some of the heaps on Panbula River, Merimbula Lake, and the shore lines of others of the lakes and estuaries of this part of the coast. In none of the heaps that were excavated during my late visit, did I see any human remains, even an isolated bone, and the only specimens which might possibly have been implements, were some rough fragments of rock with a somewhat sharp edge, not however artificially produced, which may have been used to open or break the shells of the molluscs, for the purpose of getting at the edible portion. One of these possesses a form rudely resembling a tomahawk but having no ground or polished edge. Near the bottom of the heap excavated at Shell Point on the Wagonga River, a flattish pebble of sandstone was met with, having the following dimensions, length seven inches and four-fifths, breadth four inches and nine-tenths, thickness two inches and one-tenth. On both surfaces there are unmistakeable shallow groovings which have undoubtedly been produced by the grinding on them of some implements or weapons, probably tomahawks.

On the steeply-sloping banks of the Panbula River, the empty shells are present up to a height of over thirty feet, and reach down to high-water-mark. It seems curious to imagine that the Aborigines would go to the trouble of carrying the

molluscs to such a height, before they ate them, and their presence here rather suggests the possibility of the alteration of level of the coast-line within geologically recent times. This subject is treated of in a paper by my colleagues, Messrs. David and Etheridge, in the present number of the Records. In that paper there is a considerable amount of evidence to show that since Tertiary times (to speak broadly) the relations of the sea and land have not remained permanent along our eastern coast-line. The evidence for a Post-Tertiary elevation of the coast-line is deduced in the paper referred to from a study of the raised beaches, &c., among which no traces of man have yet been found, and it is therefore hypothetical to assume that any elevation has taken place within the human period. While examining the shell-heaps described in this paper the question of a geologically recent raising of the coast-line had suggested itself to my mind, and a few facts which seem to bear upon this subject may be here stated. Very few of the extensive saltwater lakes which occur so numerously along this part of the coast are now permanently open to the sea. If this coast-line had, within recent times, undergone a partial raising, the bottoms of these lakes would also have been raised, and this would lessen the depth of water at their entrances, which would thereby greatly facilitate the silting up of their openings. Again, there are numberless instances along the coast of extensive flats which are now dry land, but which have all the appearance of having been lakes, or estuaries, at no very distant date. As an instance, we have the Tilba Tilba Swamp, at the foot of Mount Dromedary, which has quite evidently been at a very recent period a lake, although there is no human record of the fact. Again, there was, in the early days of the settlement of this part of the Colony by the whites, a tradition among the Aborigines that a few generations back sharks were speared by their ancestors above the bridge which now crosses the Punkally Creek, in a position which is now an extensive marsh land. It is, of course, quite within the range of possibility that in both the instances given, the Tilba Tilba Swamp, and the marshy flat on Punkally Creek might have been silted up by the material carried down by the creeks which flowed through them. Taken in conjunction, however, with these few facts, the presence of the shell-heaps at so considerable a height above the present sea-level would at least indicate that the subject is worth investigating, in this district, to help to establish the fact whether or not there has been an elevation of the coast-line within the human period.

In conclusion, it may be stated that, as the rocks of this district are almost entirely devoid of limestone, which could be utilised by the settlers for building and other purposes, these shell-heaps, with their interesting contents, are gradually disappearing, the mounds being dug into and the shells burnt for the lime that they will produce. Although this is to a certain extent a necessity, it seems to me a great pity that the valuable geological information which they contain should thus, in a very short time, be lost to science.

VIII.—On some beautifully-formed Stone Spear-heads, from Kimberley, North-west Australia; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate VI.]

THE Mining and Geological Museum is indebted to the kindness of Mr. T. H. Nesbitt, of Nowra, for the presentation of the stone Spear-heads represented in Pl. VI, from the Ord River, Kimberley. They were obtained during the surprise of a black's camp by the police, the tribe having had little or no intercourse with white men. The Technological Museum, Melbourne, possesses four other and similar specimens, if anything in a better state of preservation than those here figured. Mr. Rule, of that Institution, informs me that these spear-heads are made by the Leopold Range blacks and bartered to those of the Ord River. The workmanship displayed in the execution of the heads is very remarkable, and will bear comparison with any similar productions of the Palæolithic Period of the Old World, or even those of any savage people at present using stone weapons.

The use of stone spear-heads of the present type amongst the Australian Aborigines appears to be the exception and not the rule, judging from the limited number of recorded instances of their use—in fact, such weapons seem to be almost restricted to the northern coastal region of Australia, extending from Melville Island to Cape York. The late Mr. R. Brough Smyth, in describing* one of a rather different type "from the northern parts of Australia" says—"The head of one is a piece of nearly black basalt, and the others are formed of fragments of yellowish-grey granular quartzite. They are not ground or polished. They are made by striking off chips, and the form of many of them is perfect. Indeed it is scarcely to be believed that skill could be so directed as to produce from pieces of stone, by percussion only, such beautiful weapons. The length of the stone-heads is usually about eight inches. The spears are from nine to nine feet six inches in length, and the shafts are composed of a kind of reed or bamboo. They are securely fastened to the stone-heads by twine and gum."

Such spear-heads are certainly known to be in use as far west as Melville Island, for Dr. E. H. Knight, M.A., figured† three from there, exhibited in the South Australian Court at the Philadelphia Exhibition, in 1876. They are described as from four to six inches in length, and are of three types. One is similar to Smyth's figure, double sharp-edged, and angular in the middle line. The second

* Aborigines of Victoria, 1878, I, p. 308, f. 85.
† Smithsonian Institution Ann. Report for 1879 [1880], p. 268, f. 87.

is similar in shape, with saw-like serrated edges; whilst the third is simply lanceolate, and rather nondescript in character. From Cape York, stone spear-heads are recorded by Dr. J. C. Cox as made of a black, igneous, crystalline stone*; and by the late Rear-Admiral P. P. King from Port Essington†, where they were found to be four inches long, and one and a half inches broad.

That the beautiful spear-heads now figured are from the Kimberley District is to some extent borne out by the remarks of Mr. A. W. Froggatt, who says‡ that the West Kimberley natives, in addition to the hunting-spear, use the flint-headed spear. The only exception to the restriction of stone-headed spears of this description to the northern districts of Australia is a passage in Governor Eyre's work§, wherein he says, speaking of the natives of the Great Australian Bight—"They showed us several that were headed with flint, telling us that they procured it to the north-west." Lastly, the use of such spear-heads in the Northern Territory of South Australia is shown by Mr. Inspector P. Foelsche‖, who has ascertained that cicitrization is self-inflicted by both males and females, with a "sharp kind of white flint-stone, the same as is used for spear-heads."

The only previous figure of an Australian spear-head precisely similar to those here depicted is the late Rear-Admiral P. P. King's of a weapon found at Hanover Bay.¶ His remarks are so highly descriptive that no apology is needed for transcribing them here. He remarks—"But what chiefly attracted our attention was a small bundle of bark, tied up with more than usual care; upon opening it we found it contained several spear-heads, most ingeniously and curiously made of stone; they were about six inches in length, and were terminated by a very sharp point; both edges were serrated in a most surprising way; the serratures were evidently made by a sharp stone with some instrument, but it was effected without leaving the least mark of the blow; the stone was covered with red pigment, and appeared to be a flinty slate. These spear-heads were ready for fixing, and the careful manner in which they were preserved plainly showed their value, for each was separated by strips of bark, and the sharp edges protected by a covering of fur."

The spear-heads in our collection are seven in number—six chalcedonic quartz, and one of bottle-glass. There are two varieties in form—elongately lanceolate, and more or less leaf-shaped, five of the former and two of the latter; but even amongst the first-named there is a variation in outline. All the lanceolate spear-heads are angular in the middle line of one face, and flattened on the other, but one is angular on both faces; on the other hand, the leaf-shaped heads are flattened on both aspects, and it would appear that the broader they become the less angular are they in the middle line. The bi-angular specimen, composed of a much darker

* Proc. Linn. Soc. N. S. Wales, 1875, I, pt. 1, p. 25.
† Intertropical and W. Coasts of Australia, 1827, I, p. 86.
‡ Proc. Linn. Soc. N. S. Wales, 1888, III, pt. 2, p. 655.
§ Discoveries in Central Australia, &c., 1845, I, p. 209.
‖ Trans. R. Soc. S. Australia for 1881-82 [1882], V, p.
¶ Intertropical and W. Coasts of Australia, 1827, II, p. 68, pl. f. 1-3.

chalcedonic quartz than the others, even presents a triangular outline. The extreme points of four of the same specimens are broken, but in those in which the apex is preserved it is sharp and acute. The glass spear-head is truncated at the base; the others are all rounded. Five bear traces of the gum used to hold them in position on the spear, but the remaining two do not appear to have been used.

The chalcedonic quartz is probably derived from some of the Desert Sandstone beds of the north-central portion of the Continent. In his "Annual Report for 1883," Mr. H. Y. L. Brown describes* the capping of a large district of central South Australia as a "yellow flinty quartzite or porcellanised sandstone," varying in thickness from ten to thirty feet, intensely hard, invariably glazed, and with a conchoidal fracture. It is certainly of Supra-Cretaceous age.

For general purposes of classification, therefore, three types of serrated spear-head may be said to be present, thus:—

1. Elongately lanceolate—angular on one face, flattened on the other.
2. Elongately lanceolate, or almost triangular—angular on both faces.
3. Flattened on both faces.

The following table shows the measurements of the seven specimens:—

No.	Form.	Height.	Breadth.	Thickness.	Substance.	Apex.	Pl. VI.
		in.	in.	in.			
1	Elongately lanceolate—angular on one face.	$3\frac{7}{8}$	$1\frac{3}{8}$	$\frac{5}{16}$	White chalcedonic quartz.	Broken ...	Fig. 1.
2	"	$3\frac{1}{8}$	$1\frac{2}{8}$	$\frac{5}{16}$	Glass..................	Perfect ...	" 2.
3	"	$2\frac{1}{8}$	1	$\frac{5}{16}$	White chalcedonic quartz.	Broken ...	" 3.
4	"	$2\frac{1}{8}$	1	$\frac{4}{16}$	Variegated chalcedonic quartz.	" ...	" 4.
5	Elongately lanceolate — angled on both faces.	2	$\frac{7}{8}$	$\frac{5}{16}$	Brown chalcedonic quartz.	Perfect ...	" 5.
6	Foliolate—flattened on both faces.	$2\frac{1}{8}$	$1\frac{2}{8}$	$\frac{4}{16}$	White chalcedonic quartz.	Truncated	" 6.
7	"	$2\frac{1}{8}$	1	$\frac{4}{16}$	"	Perfect ...	" 7.

The spear-head figured by Rear-Admiral King is nearly twice the size of any of the above. It is of the lanceolate type, and was clearly bi-angular from the section given. The feature, however, which makes it so remarkable a specimen is the exceedingly coarse saw-tooth-like marginal serrations, which must have cost an infinite amount of pains to produce. In the Ord River spear-heads the margins are merely sharply serrated; but in King's figure of the Hanover Bay weapon the place of these simple serrations is taken by more or less square-headed teeth, themselves at times serrated, and separated by interspaces equal to themselves in

* South Australia—Ann. Report of the Government Geologist, with plans, &c., 1st August, 1883 (South Australian Parl. Papers, 1883, No. 46), p. 3.

breadth. Stone implements with a similar saw-like serration of the edges are figured by Mr. E. T. Stevens, from Honduras*; and by Mr. John Evans†, from the Yorkshire Wolds, but under the name of "Saws."

Now, as to the manipulation by which these spear-heads are produced, we find an interesting description by Mr. T. Baines, who accompanied Mr. A. C. Gregory in his 1855–56 Expedition through Northern Australia. Mr. Baines describes the method employed by the Victoria River blacks in the following words‡:—"The native having chosen a pebble of agate, flint, or other suitable stone, perhaps as large as an ostrich egg, sits down before a larger block, on which he strikes it so as to detach from the end a piece, leaving a flattened base for his subsequent operations. Then, holding the pebble with its base downwards, he again strikes so as to split off a piece as thin and broad as possible, tapering upward in an oval or leaf-like form, and sharp and thin at the edges. His next object is to strike off another piece nearly similar, so close as to leave a projecting angle on the stone, as sharp, straight, and perpendicular as possible. Then, again taking the pebble carefully in his hand, he aims the decisive blow, which, if he is successful, splits off another piece, with the angle running straight up its centre as a midrib, and the two edges, sharp, clear, and equal, spreading slightly from the base, and again narrowing till they meet the midrib in a keen and taper point. If he has done this well he possesses a perfect weapon, but at least three chips must have been formed in making it." Such an operation would result in the production of pieces roughly shaped like our spear-heads, but the facets and marginal serration are clearly produced by further chipping, for which, undoubtedly, very delicate manipulation is required.

The other forms of stone-armed spears used in Australia known to the writer are two in number. There is the *Mongile*, or as the natives of Lake Tyers call it, *Wal*, consisting of chips of a hard black basalt, or other suitable stone, inserted in a groove along each side of the apex of the spear, and kept in their places by gum.§ This is termed by Eyre, *Karkuroo*, being barbed in South Australia by flint or quartz.‖ Both the figures of Smyth and Eyre represent this spear as a most formidable weapon, more especially that of the former. A somewhat conventional figure of this spear is given by Dr. Knight in his "Study of the Savage Weapons at the Centennial Exhibition, Philadelphia, 1876."¶ This would appear to be the form of stone spear common throughout Southern Australia—at any rate, it exists from the Great Australian Bight, where it was seen in use by Eyre, to the Grampians in Victoria, for Sir T. L. Mitchell mentions** such a spear at Mount Aripiles in that range.

* Flint Chips, 1870, p. 289, frontispiece.
† Ancient Stone Implements, &c., Gt. Brit., 1872, p. 265, f. 109.
‡ Journ. Anthrop. Soc., Lond., 1866, IV, p. CIV.
§ Aborigines of Victoria, 1878, I, p. 304, f. 68.
‖ Discoveries in Central Australia, 1845, II, p. 306, t. 4, f. 9 and 10.
¶ Smithsonian Institution Ann. Report for 1879 [1880] p. 266, f. 93.
** Three Expeditions into the Interior of Eastern Australia, 1838, II, p. 193.

The second form is only known from a figure by the late Mr. R. B. Smyth.* It is said to come from the "Far North," and consists of greenstone, polished and brought to a point. It is quite unlike any other known form of Australian spear-head.

The third kind of spear is met with in Western Australia, and is called *Gidjee*, *Gee-jee*, or *Borral*. The head of the spear, says Smyth,† is covered with a hard gum, thicker on one side than the other, and forming a bed in which pieces of stone or glass are implanted.

We have thus in Australia at least four, and perhaps five types of wholly or partially stone-headed spears,—

1. Simple double-edged, lanceolate, three-faced heads, with a more or less entire margin. Melville Island, Port Essington, and Cape York.

2. Double-edged, three-faced, lanceolate heads, with the cutting edges serrated in a greater or less degree. North-west Australia (Kimberley, Ord River, &c.)

3. Wooden spear-heads barbed on both sides with fragments of sharp stone, and called *Karkuroo*, *Mongile*, or *Wal*. Great Australian Bight to Grampians in Victoria.

4. Wooden spear-heads barbed on one side only, called *Gidjee*, &c. Western Australia.

5. Well-shaped, rounded, and pointed polished heads of greenstone. (Smyth, *Loc. cit.* I, p. 309, f. 87), North Australia ("Far North.")

* Aborigines of Victoria, 1878, I, p. 309, f. 87.
† Aborigines of Victoria, 1878, I, p. 336, f. 141.

IX.—Notes on the Gunnedah Coal-field; by G. A. STONIER, Geological Surveyor.

I.—Section of Seams I and II, with Analyses of the Coal.

THE first official notice of the Gunnedah Coal-field is to be found in a Report made by Mr. Geological-Surveyor T. W. E. David, B.A., F.G.S., and published in the Annual Report of the Department of Mines for 1886.* The following may be taken as a summary of the more important facts alluded to:—

No. of seam.	No. of portion.	Section of strata and seam.	Analyses.	Upper portion.	Lower portion.	Remarks.
I	53 (John Pryor).	50′ basalt. 17′ hard shale passing into strong coal. 6′ 4″ coal-seam. Floor—sandy shale.	Hygroscopic moisture ...	3·00	2·80	Discovered in a well sunk for water on the edge of the flat.
			Volatile hydrocarbons ...	29·50	30·47	
			Fixed carbon	58·80	56·83	
			Ash	8·70	9·90	
				100·00	100·00	
			Specific gravity	1·291	1·278	
			Sulphur	0·61 %	0·52 %	
			Coke.........................	Nil.	66·73 %	
II	16 John Darcey (now J. Melville).	Roof sandstone 4′ 9″ x, coal seam (probably 7′ 0″)	Hygroscopic moisture ...	3·10		Do.
			Volatile hydrocarbons ..	39·60		
			Fixed carbon	48·23		
			Ash	9·07		
				100·00		
			Specific gravity	1·281		
			Sulphur	0·78 %		
			Coke................	57·3 %.		

Mr. David remarks (*loc. cit.*) . . . . "It would appear that Darcey's seam is considerably below Pryor's . . . . . The absence of marine fossils at Black Jack, taken into consideration with the fact that here the strata are dipping off beds, which at Somerton, twenty-seven miles to the east, contain marine Carboniferous fossils, favours the supposition that the Gunnedah coal belongs to the East Maitland, or to the Newcastle Series."

The publication of the Report referred to above, attracted speculators and others to the field, and as both properties on which the coal had been found were six miles from the town of Gunnedah, the attention of prospectors was directed to the country nearer the railway line, and this has resulted in the discovery of two seams which are known locally as:—

No. III, M'Cosker's Seam.
No. IV, Curlewis' Seam.

* 1887, p. 151.

No. III occurs in the ranges behind Pryor's house at Gunnedah.

No. IV was discovered at Curlewis by the Messrs. Poole on land which is now the property of the Centenary Coal and Coke Company, and which is only two miles from the railway. A line to connect the mine with the railway has been almost completed. Its construction has been an easy matter, the gently sloping character of the surface of the ground presenting no engineering difficulties to be overcome. As Curlewis is ten miles nearer to Werris Creek than Gunnedah, the station where the Narrabri and Great Northern lines meet, it is in a more favourable position for the disposal of its coal for the supply of the Great Northern line than any mine yet opened at Gunnedah.

The discovery of both No. III and IV Seams was due entirely to careful prospecting, and when the small thickness of measures exposed is considered, as well as the facts that—

(*a*) The seams have been decomposed for such a distance from the crop, and to such an extent as to permit their floors and roofs almost to touch one another.

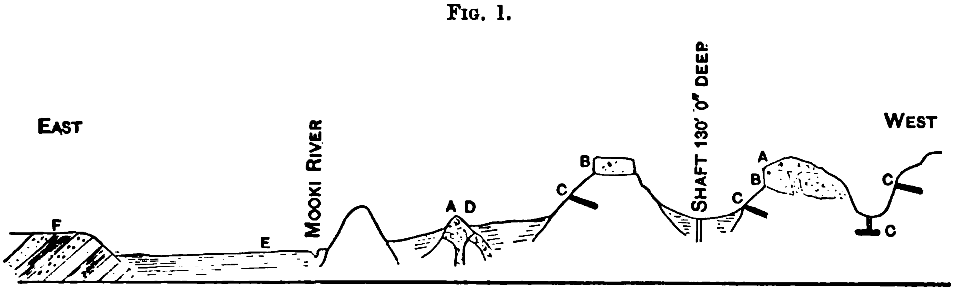
(*b*) Drift blocks of coal, which are such an invaluable assistance when prospecting for the crop of a seam, are never found in the waterways—

it is but little wonder that these fuel deposits have been untouched for so long a time.

Important as was the actual finding of coal in both Darcey's and Pryor's Wells, the section of the beds given by these wells was of little value as a guide for prospecting work in other parts of the district; the strata, too, in the range behind Pryor's house has been much disturbed, and no persistent bed has been noticed which can be taken as a datum line from which to trace out the crops of the seams and to work out the geological structure of the district, so that the prospecting has been necessarily rather haphazard.

At Curlewis, however, a well-marked bed is found in the form of a jasper conglomerate which occurs as a mural precipice, and makes quite a feature in the hill scenery. Its thickness is at least fifty feet, and it can be traced from the company's working tunnel on M.L. 17 for a distance of six miles south-easterly until the hills are lost, and black and red soil country commences, which latter, as shown on the following longitudinal sketch section, extends for some miles further in the same direction.

FIG. 1.



A Basalt. B Jasper conglomerate. C Coal seams. D Red soil. E Black soil. F Devonian (?) sandstones, conglomerates, &c.

From the Curlewis Mine westwards towards Pryor's shaft the country has not been geologically explored, but a bed, which in its occurrence very much resembles the jasper conglomerate, can readily be distinguished in several of the hills between Gunnedah and Curlewis, which are close to the railway. At the Gunnedah coal land, the bed itself has not been noted actually in position, but in a gully near Mr. M'Cosker's Tunnel, several large and loose blocks of it occur. Time, however, did not permit of their being traced to any particular horizon. The hill on which they are found has been much disturbed, and in places quite shattered by intrusive basalt.

The bed has been called jasper conglomerate from the number of jasperoid-quartz and quartzite pebbles from two inches to eight inches in diameter, which are found in it, and render its recognition an easy matter. The pebbles are mostly well rounded, and in addition to the jasper pebbles are quartz pellucid, white and opaque, and altered sandstone with a few quartz porphyry and felspar porphyry pebbles in a greyish-white, sandy matrix. Many of the latter pebbles are coated with ferric-oxide, and on this account those of jasper appear to be in greater quantity than is actually the case.

II.—Sections of Seams III and IV, with Analyses of the Coal.

The following are sections of the Seams Nos. III and IV, together with analyses of the coal. The former have been taken by the author, and the latter made by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department of Mines:—

SECTIONS OF THE SEAMS.

No. III, M'Cosker.		No. IV, Curlewis.	
	Roof.		Roof.
Analysis A......	1 ft. 9 in., dull splint coal.	Analysis C......	10 ft., inferior splint coal, with bands.
,, B.....	5 ft. 6 in., splint with thin layers of bright bituminous coal.	,, D.....	1 ft. 6 in., dull splint coal.
	Floor—Bluish-gray clay shale.	,, E.....	4 ft. 6 in., splint with thin layers of bright bituminous coal.
			Floor—Bluish-gray clay shale.

PROXIMATE ANALYSES.

	A	B	C	D	E
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hygroscopic moisture ...	4·36	3·70	3·05	3·10	3·16
Volatile hydrocarbons...	26·52	32·79	19·25	29·40	33·08
Fixed carbon..............	61·47	52·48	48·62	58·47	50·12
Ash	7·65	11·03	29·08	9·03	13·64
	100·00	100·00	100·00	100·00	100·00
Specific gravity...........	1·378	1·365	1·5960	1·404	1·363
Sulphur	1·170	0·617	0·3570	0·357	0·768
Coke	Slightly caked.	63·510	—	67·500	63·76
Ash	Pinkish colour. Dense.	Light-gray Dense.		Light-gray in colour, no copper detected.	Dark-gray in colour. On an examination being made of the ash, a strong trace of copper was detected. The coal was examined by aid of the microscope, and small patches of copper pyrites were plainly visible.

At Curlewis the seams cannot be depended upon for any distance, as they have been proved to pass in places into bituminous shales, with bright black bituminous coal pipes.

It will be noticed on reference to the above analyses that copper pyrites has been detected in sample E. Iron pyrites is noticeable on some of the joint faces of the coal, but for the determination of copper pyrites something more than the unaided eye is necessary. The occurrence of metals other than iron in coal is by no means a recent discovery, for in the year 1851, Daubrée (Percy on Fuel, p. 276) found traces of arsenic and antimony in the coal of Newcastle-on-Tyne, and samples from other localities have been found to contain antimony, arsenic, and copper, and in some British coals galena also occurs. This, however, is believed to be the first recorded occurrence of copper in connection with coal in New South Wales.

III.—*Correlation of the various Seams.*

It would appear from the report of Mr. T. W. E. David, that Seams I and II are distinct, and that No. II underlies No. I, with probably some thickness of strata separating them. At first sight the relation of No. III to either No. I or No. II is not very clear, as the latter are found in shafts on the flat country, while the former occurs in the range, and two hundred and forty feet (actual altitude) above No. I. Owing to the late rains the shafts on the flat could not be examined at the time of the author's visit, but Mr. J. Mackenzie, F.G.S., the Examiner of Coal-fields, has seen the three sections, and verbally states, that he

onsiders No. I and No. III to be identical. The dip at Pryor's Well is W. 10° N. at 9½°, and at M'Cosker's Tunnel it is W. 25° S. at 5°, and these two points are about half-a-mile distant in about a meridianal direction, so that the difference in altitude can only be accounted for by a fault, the trend and actual position of which has not, up to the present, been determined.

The analysis of the coal and sections of seams favour Mr. Mackenzie's opinion.

For the elucidation of the question of the relations of the Curlewis to the Gunnedah Seams, there is but slight evidence. The clearest facts are:—

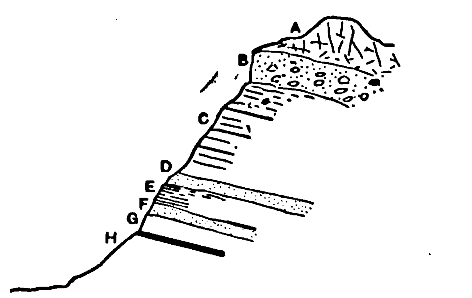
(*a*) Similarity in composition of the Curlewis coal to that of Seams Nos. I and III.

(*b*) Similarity in sections of Seams Nos. I, III, and IV.

(*c*) Similarity in roof and floor of Seams Nos. I, III, and IV.

These facts considered alone would lead to the conclusion that the Curlewis Seam was identical with Seams Nos. I and III, but a comparison of the strata above the seams does not at all favour this view. The lithological difference in the measures is rather decided, for at Curlewis there are two well-marked beds of sandstone, which occur as shown on the following sketch section:—

FIG. 2.



Thicknesses are only approximate.

A Basalt.
B 50 feet jasper conglomerate.
C 175 feet strata (hidden), probably chiefly sandy-shales.
D 4 feet fine-grained sandstone, cherty in places.
E 45 feet sandy-shales.
F 5 feet quartz grit.
G 40 feet sandy-shales and bituminous shales passing into inferior splint coal.
H 6 feet coal seam.

The thickness between the two sandstone beds, and between them and the jasper conglomerate, varies in places, but the two beds themselves are invariably developed at Curlewis, whereas at Gunnedah there is no sign of either bed, nor, so far as has been observed up to the present, do the strata above the coal at the latter locality appear to bear any resemblance to those overlying the coal at the Curlewis section.

If the Curlewis Seam be not No. I, it is evident from the analyses of the coal, section of the seams, and difference in their respective floors and roofs, that it cannot be No. II Seam; but as loose blocks of the jasper conglomerate, so well developed at Curlewis, are found at Gunnedah, and in about the same position with reference to the coal, it is probable that there may be no very great thickness of strata separating the Curlewis from the Gunnedah Seams.

IV.—*Age of the Measures.*

At Curlewis *Glossopteris* and *Vertebraria* occur in abundance in the Coal-Measures, thus proving them to be Permo-Carboniferous. The latter fossil was observed to be in most cases vertical to the stratification of the beds. No marine fossils have been noticed, nor has any evidence been obtained which will definitely determine the beds as belonging to the Newcastle or to the East Maitland Series, to one of which Mr. David considers the Gunnedah measures to belong.

A Report on the Curlewis District will be published in the Annual Report of the Department of Mines for 1890.

X.—Note on the Occurrence of Fish-remains in the Rocks of the Drummond Range, Central Queensland; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

IN 1882 the late Rev. J. E. T. Woods announced the discovery of plant-remains* in the rocks of the Drummond Range, Central Queensland. The fossils were found in sandstone blocks at Bobuntungen, and are ascribed to the age of the Lower Carboniferous. The species determined by Mr. Woods were the following:—

Calamites varians, Germar.
Calamites radiatus, „
Cyclostigma australe, Feistmantel.
Lepidodendron veltheimianum, Sternberg.

To these were subsequently added †:—

Neuropteris (allied to *N. gigantea*).
Lepidodendron nothum, (Unger) Carruthers.
Cordaites australis, M'Coy. (?)

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* A Fossil Plant Formation in Central Queensland. *Journ. R. Soc. N. S. Wales for* 1882 [1883], XVI, p. 179.
† On the Fossil Flora of the Coal Deposits of Australia. *Proc. Linn. Soc. N. S. Wales for* 1880, [1884], VIII, pp. 90, 135, 155.

Mr. Woods considered the beds containing these, as before stated, to be of Lower Carboniferous age, and the equivalents of those at Smith's Creek, near Stroud, and Goonoo Goonoo, near Tamworth, New South Wales.*

Mr. R. L. Jack gives the thickness of the Drummond Range beds at not less than two thousand feet, admirable sections being visible on the Central Railway, between Pine Hills Station and Bobuntungen, the latter being the centre of a synclinal trough.

Some months ago Mr. C. T. Musson, F.L.S., presented to the Mining and Geological Museum numerous pieces of greenish sandy micaceous hard shale, collected by himself, in the Drummond Range, with small fish scales and plates scattered over them. So far as I am aware this is the first discovery of any other organic remains in the Drummond Range series, other than those of plants. It is of importance, notwithstanding the fact that the scales are too indefinite to determine even the genus satisfactorily, as giving weight to the hitherto supposed age of the beds in question. On examining the scales and other plates they struck me at once as those of a Palæoniscid, but before finally adopting this view, I forwarded drawings to Mr. A. S. Woodward, of the British Museum, who confirmed it.

The scales are either inclined to oat-shaped, or rhomboidal, grooved and pitted; some of the grooves anastomosing, others concentrically arranged on the scales. There are also a very few fragments of bone, which, as well as some of the scales, are partially converted into vivianite. The oat-shaped scales are about three-sixteenths of an inch long; the rhomboidal scales two-sixteenths of an inch; and there is a third form, rather inclined to a pentagonal outline, two-sixteenths of an inch long, by a little more than one-sixteenth broad; but modifications of the oat-shaped scale are the commonest.

Mr. Musson has favoured me with the following notes on the locality:—

"On and around a small ridge half-a-mile from, and to the north of the Bogantungan Railway Station, I found numerous fish remains consisting of scales and spines in nodules from what appear to be Carboniferous shales, the beds dipping east, and apparently continuous with those of a similar character developed at the east end of the cutting in the range, some two or three miles away. The fossils occur in nodules, which are seen to rest in thin bands in a section showing hard and soft beds of a peculiar dark-greenish clay (mapped Carboniferous by the Geological Survey), with other harder bands in thin layers, which are sometimes seen to cap the ridges. The fossils were found in situ, and lying about the gullies, of which there are three. The beds rest on a coarse gritty rock in places of a crystalline character. The hard fossiliferous bands vary considerably in themselves, and show evidence of having been altered from their original condition."

* Journ. R. Soc. N. S. Wales, *loc. cit.* p. 189.

XI.—Description of some Stone Weapons and Implements, used by the Aborigines of New South Wales; by WILLIAM ANDERSON, Geological Surveyor.

RELICS of the Aborigines, who inhabited this Colony, before the advent of Europeans, and who, as a race, are now nearly extinct, are frequently met with during the prosecution of our geological work in various parts of the country, and as these evidences, will, in course of time, be of the utmost scientific interest and value, it is important that a record of them should be kept.

The collections described in this paper consist of stone tomahawks, which were used by the blacks, as offensive weapons and implements; together with a nardoo grinder, and two flat fragments of rock which have been used as portable surfaces on which the cutting edges of tomahawks have been sharpened.

The first ten specimens were given to me some time ago by the Rev. J. Milne Curran, then of Cobar. No. 35 was, however, picked up by myself at the edge of Byrock Water-hole, fifty miles south of Bourke, and No. 36 was found on Yanda Run to the west of Bourke. They had all been used by the Aborigines of the Darling District, and some of them are certainly of local production, as the rocks of which they are made can be readily identified with rocks which occur *in situ* in the district. A number of them have, evidently, been originally well-rounded water-worn pebbles, while the others have been naturally denuded rock fragments which have been picked up by the Aborigines, because of their apparent adaptability for taking a cutting edge, and for use thereafter as an offensive weapon or implement. As a necessary consequence of their original condition as pebbles, and fragments of rock, there is, among them, no uniformity in size or shape; the only general point of resemblance being in the presence of a ground cutting edge. The extent to which the surfaces have been smoothed and polished in the neighbourhood of the cutting edge, varies greatly in the individual specimens, and seems to have depended chiefly upon the texture and hardness of the rock, as well as the amount of painstaking care which was expended in shaping that edge. More labour seems to have been bestowed upon the finer grained and more compact rocks which would be better adapted for taking a high polish, and a true and lasting edge. What smoothing and polishing of the surfaces of the weapon has taken place, has been due, more to the efforts to produce the cutting edge, than to any intentional desire to polish the whole weapon. This I think is evident when we consider the method by which the cutting edge was produced.

All the specimens are longer than they are broad, and this seems to be a characteristic feature of the stone tomahawks used by the Aborigines. In their narrower section they are somewhat flattened, although some are nearly circular or oval. The butt-end of the weapon is never worked, the only portion artificially ground and smoothed being the cutting edge, and varying portions of the faces in its neighbourhood. In most cases an effort has evidently been made to increase the extent of the cutting edge by reducing the length of the pebble, and thus increasing the width of the end to be sharpened. The cutting edge is rarely perfectly straight, but generally possesses a slight curvature in the line of its greatest width. The angle which the smoothed portions of the faces make with each other to form the cutting edge varies considerably, and seems to have depended entirely on the original thickness of the pebble. The ground surfaces containing that angle when thoroughly finished are never flat, but slightly convex; this no doubt, is due to the fact, that in the process of sharpening, the weapon was not held steady, but an undulatory motion was given to it, as it was rubbed in the grooved surface on which the sharpening was accomplished. It is, I think, pretty certain, that, in perfecting the cutting edge of their stone tomahawks the Aborigines endeavoured to obtain an edge, the curved outline of which was distinctive and was a definite factor in their conception of what a perfect weapon should possess. There is great diversity in the degree of perfection to which the individual weapons have been worked. This has been chiefly due, no doubt, to the degree of adaptability which the various rock fragments possessed, of being developed into perfectly-edged weapons, and also to the amount of skill and patience displayed by the individual in manipulating the weapon during the process of grinding. Many of the pebbles have to a certain extent been naturally smoothed by attrition, but most of them present very irregular rough surfaces, and none of them have been artificially chipped, as is the case with the palæolithic stone implements of other countries.

Collection (*a*) may be conveniently divided into two groups, the distinction between them consisting in the difference of character of the original rock fragments, from which the weapons were formed. This division although convenient for the purposes of this paper is by no means arbitrary.

The first group consists of six specimens, Nos. 24, 25, 26, 29, 35, and 36, all of which have undoubtedly been originally well water-worn and rounded pebbles, evidently picked out of some creek-bed. The entire surfaces of No. 36 are highly polished, but this has not been artificially produced, but has been due to natural agencies, as it is quite evident that it was originally a pebble in the conglomerates of Gundabooka Mountain to the west of Bourke. Another peculiarity about this specimen is, that the cutting edge, which is perfect, is nearly straight, thereby differing from all the others of this group in which the edge has a slight curvature. The cutting edge of No. 26 is slightly curved, and is most perfectly finished, the

The following is a tabular view of the dimensions of the various weapons described in this paper:—

	No. of Specimen.		Locality of Rock.	Locality of Specimen.	Greatest diameter.	Greatest breadth.	Greatest thickness.	Extent of cutting edge.	
					in.				
Group I.	24	Leucite basalt ...	El Capitan, 35 miles N.E. of Cobar or Byrock Mt.; 50 miles S. of Bourke.	Cobar District	3⅛	2 in. midway between butt and cutting edge.	1⅛ in. about middle of weapon.	1⅛ in. edge curved	Collection (*a*).
	25	Granite (porphyritic).	....	,, ,,	3⅛	2 9/10 in. near butt	1⅛ in. at butt	2 7/10 in. ,, ,,	
	26	Fragmental rock	....	,, ,	3⅜	1 7/10 in. at butt	1⅛ in.	1⅜ in. ,, ,,	
	29	Diorite	....	,, ,,	3 3/10	2 3/10 in. cutting edge......	1⅛ in. near butt ...	2 3/10 in. ,, ,,	
	35	Fragmental rock	....	Byrock Water-hole.	3 3/10	1 9/10 in. near cutting edge	1½ in. ,, ...	Edge chipped away	
	36	Argillite	Conglomerate, Gundabooka Mt.	Bourke District	4⅜	3⅛ in. midway between butt and cutting edge.	1⅜ in. near one edge of weapon.	2⅝ in., edge straight	
Group II.	23	Leucite basalt ...	El Capitan, 35 miles N.E. of Cobar or Byrock Mt.; 50 miles S. of Bourke.	Cobar District	5⅛	3½ in. near base of cutting edge.	1⅝ in. near butt ...	Slightly ground on natural curvature of fragment.	
	27	Syenite	....	,, ,,	3 7/10	2 1/10 in. middle of weapon	1 1/10 in. ,, ...	1 7/10 in.	
	28	Fragmental rock	....	,, ,,	3 7/10	2⅞ in. near cutting edge	1 7/10 in. middle of weapon.	2⅜ in.	
	30	Diorite	....	,, ,,	3⅜	2⅛ in. middle of weapon	1⅛ in. ,, ,,	2 in.	
	31	Fragmental rock	....	,, ,,	3⅝	2⅜ in. near cutting edge	0⅞ in. at butt	2¼ in.	
	32	Basalt	....	,, ,,	2 7/10	2 in. middle of weapon...	1 in. middle of weapon.	1⅜ in.	
	38	Kiastolite slate...	....	Borolong, New England.	4⅛	3½ in. ,, ,, ...	1⅜ in. ,, ,,	1⅜ in.	Collection (*b*).
	39	Volcanic tuff (?)	....	,, ,,	5	2⅜ in. ,, ,, ...	1 3/10 in. ,, ,,	Edge not ground...	
	40	Siliceous claystone.	....	,, ,,	4⅜	3 in. ,, ,, ...	1 3/10 in. ,, ,,	,, ,, ...	
	41	Claystone	....	,, ,,	4 9/10	2⅛ in. ,, ,, ...	1⅛ in. ,, ,,	2 1/10 in.	
	42	Aphanite	....	,, ,,	4	2⅛ in. ,, ,, ...	0⅞ in. near butt ...	2 in.	
	43	Basalt (?)	....	,, ,,	3 7/10	2 7/10 in. ,, ,, ...	1 in. ,, ...	1 1/10 in.	

faces enclosing it being highly polished by artificial means. The same may be said of No. 29. A large fragment has been accidentally chipped out of the cutting edge of No. 35, but whether this has occurred while the weapon was in use, or subsequently, there are no means of determining from the specimen itself. As shown by the measurements given in the table (p. 75), all, with the exception of No. 36, have an oval or rounded section at right angles to their longer diameter.

The second group also comprises six specimens, Nos. 23, 27, 28, 30, 31, 32, all of them having evidently been weathered rock fragments, not showing any decided result of the action of stream-water. They are generally flat, with the exception of No. 28, which is one inch and seven-tenths in thickness. This latter specimen with Nos. 30 and 31 possess well finished cutting edges, the two former being slightly curved and the last nearly straight. The faces enclosing these edges are polished to a variable extent towards the butt of the weapon. The cutting edges of Nos. 23, 27, and 31 are but rudely formed and have undergone but little grinding. The butt end of No. 30 presents a minutely pitted surface, which may possibly have been produced artificially.

I think, it is evident, from a study of this collection of weapons, that there was no endeavour on the part of the Aborigines who formed them to obtain an artistic effect by polishing the whole surface, or by at all shaping the butt end of the weapon. Their chief desire seems to have been to produce a weapon having a perfect cutting edge, although they seem to have exhibited a certain amount of discrimination in picking up the rock specimens from which to form their weapons, showing a preference for such fragments or pebbles, whose shape and hardness appeared to be adapted for producing a weapon which would possess a perfect cutting edge, and would allow of its being conveniently used as such when formed. The polishing of portions of the surfaces was undoubtedly accidental, being due to the method employed in shaping the cutting edge of the weapon.

The second collection of stone weapons consists of six specimens, which were sent to me by Mr. Bloomfield of Borolong, near Armidale, on the New England Table-land.

Five of them differ widely in type from the collection just described from the Darling District, in the fact that they have undoubtedly been artificially chipped into their present form, instead of being merely pebbles or rock fragments sharpened by grinding at one end. The sixth specimen (No. 38) is however a flattish water-worn pebble of kiastolite slate, the narrower end of which has been slightly ground to an edge, which is of very small extent and not at all polished, no effort having been made to chip the pebble into a definite shape. A tomahawk, composed of a similar rock, is mentioned by my colleague Mr. T. W. E. David, in a note, on the rare occurrence of the rock in this Colony.*

* Proc. Linn. Soc. N. S. Wales, 1887, II., p. 1084.

The other five specimens may be divided into two groups, the former comprising two (Nos. 39 and 40), which are simply chipped, and the latter consisting of three (Nos. 41, 42, 43), which in addition to being chipped possess a ground, but not a polished cutting edge. Taking the first group (Nos. 39 and 40) it is seen that the only work expended on them is the chipping of the edges and greater portions of both faces. In the centres of the chipped faces, however, portions of the original decomposed surfaces of the rock fragments are still visible, showing that they have been formed from rock fragments which were probably picked up and not quarried from a rock mass by the workmen who chipped them into shape. In both cases the entire peripheries of the specimens have been chipped, and it would appear as if their method of procedure had been to work from the edges towards the centres of the faces. The general surfaces and edges, around the butt of the weapon have large flakes chipped off, while the edge which was evidently meant to represent the cutting edge is minutely chipped, particularly on one face of No. 40. An effort has been made to obtain on this specimen a curved cutting edge as near as possible on one plane. The cutting edge of No. 39 is irregular and sinuous, and of the two, No. 40 presents the more finished workmanship. It is uncertain whether these specimens are unfinished weapons, and thereby represent an intermediate stage in the formation of the more perfect forms of the next group, where, in addition to chipping, one end has been ground to a fine edge. I think from our present scant knowledge of the evolution of aboriginal stone-weapons, that this is more likely to be the case, than to suppose that those specimens which are merely chipped were used as finished weapons by the Aborigines of an earlier period than the present, and that therefore they would represent a lower phase of culture in the workman who made them than that possessed by the late Aborigines of the Colony. Additional force is given to this supposition by the fact that in the district in which these weapons were found, there occur quarries to which the Aborigines have been known to resort for the purpose of obtaining rock fragments from which to form their weapons. In and around these quarries numbers of chips and unfinished tomahawks, spoiled in the making, occur abundantly.

The second group differs from the two specimens last described, in the fact that they are not only chipped, but possess a cutting edge at one end, produced by grinding the two faces. The entire surfaces of No. 41 have been chipped, while on one face of No. 43, a small portion of the original decomposed surface of the rock-fragment is left unchipped. The edges only of No. 42, and a small portion of the faces in their neighbourhood have been worked, the larger portion of both faces being untouched. An effort has been made in all three cases to grind a cutting edge at one end of the weapon, and it is evident from the remains of the hollows, left by the flakes, which have not been wholly obliterated in the process of grinding, that the edge was first roughly formed by chipping, and subsequently

smoothed. The extent to which the grinding has taken place varies much in the three specimens, and in no case is the ground face polished. The most perfect edge is that produced on No. 41, where a considerable portion of both faces has been ground. One face of No. 42 is more ground than the other, while the cutting edge of No. 43 is of very small extent, and the ground portion of the faces is exceedingly limited. The form of this specimen is somewhat peculiar and unusual, the width of the cutting edge being hardly half the width of the butt of the weapon.

In the formation of these weapons from New England, the various specimens show that they underwent three stages, or processes, in their development into perfect weapons. First, large flakes were chipped off the rock fragments to produce the required form (No. 39), then a series of minute flakes were taken off one end to form roughly the cutting edge (No. 40), and lastly this minutely chipped end was ground to a smooth, sharp, and curved edge.

It is evident, I think, from the rough description that has been given of these two collections, from two widely separated districts of this Colony, that the differences in the methods employed in their formation represent different stages of culture in the workmen who produced them. In the case of the collection from the Darling District, the Aborigines in forming their stone weapons have not exhibited the same degree of culture that is shown by the New England specimens, where the rock fragments have first been chipped into a definite and desired shape before a beginning was made to grind a sharp cutting edge upon them, but they have ground and polished rock fragments, which, to a certain extent, had already been formed by natural agencies into a shape which rudely represented the desirable form. The presence, however, of weapons, formed only by rudely grinding one end of a pebble among those chipped and ground specimens from the New England District would seem to indicate that although the latter was the chief method employed, yet the former was also to a certain extent adopted. Again in those specimens from the Darling District, which have been formed from rough unwater-worn rock fragments, no effort has been made to produce in them a uniform shape, the only work expended on them being in the production by grinding of a cutting edge. It would, therefore, appear to me that we have in the New England specimens a stage of culture, in the formation of their stone weapons, which is midway between, or rather a combination of, the rudely chipped and irregularly shaped weapons of the Aborigines of Tasmania, and the highly polished and perfectly ground tomahawks, possessed by some of the tribes on this continent; and that the evolution of the latter may have taken place in the following order. The most primitive are the rudely chipped rock fragments of no distinctive form (Tasmanian), passing through those which have been chipped into a definite shape (Nos. 39 and 40, New England Collection), into the definitely formed chipped

specimens with a rudely ground cutting edge (Nos. 41, 42, 43, New England Collection). Next, the unchipped pebbles and rock fragments, having a more or less distinctive form, not produced artificially, possessing a perfect cutting edge, produced only by grinding, and having the surfaces partially polished; and lastly, those forms, which have the whole surfaces ground and polished, producing a distinctive and uniform shape, and which are the most highly finished weapons of the whole series. Some of these stages were undoubtedly contemporaneous, and they do not therefore represent individual and consecutive human periods.

Most of the tomahawks from the Cobar and Bourke Districts are known to have been in use by the Aborigines of these districts, so that they are of comparatively recent date. The specimens from New England were picked up at various times in the neighbourhood of Borolong, but no evidence can be deduced from the specimens themselves, as to whether or not they are of modern manufacture, although it is very probable that they are.

The three implements, Nos. 33, 34, and 37, may be shortly noticed here:—

Nos. 33 and 34 are flat fragments of sandstone, whose surfaces have evidently been used by the Aborigines upon which to grind the cutting edges of their tomahawks. They have been artificially shaped into their present form in order to make them portable. They were both obtained from the Cobar District of the Great Western Plains. It was the common practice among the Aborigines who frequented these plains to carry such implements with them, because the localities are so few in that flat country, where the outcrops of hard rocks occur, upon which they could grind their weapons, that it was a necessity with them to carry such fragments for the purpose of sharpening their tomahawks. In the mountainous and hilly parts of the Colony numerous places occur where exposed rock surfaces are still to be seen covered with small grooves which have been used for generations by the Aborigines for the purpose of shaping the edges of their weapons.

No. 33 is a fragment of ferruginous sandstone four and a-half inches long, two inches and three-tenths broad, and three-fifths of an inch thick. One of its surfaces is quite flat, while the other is indented by a wide groove which occupies nearly the entire length and breadth of the surface. It is situated nearer to one end of the fragment than to the other, and has been excavated more than half-way through the thickness of the stone. The groove has been produced by the repeated grinding of stone weapons upon the surface of the fragment of sandstone. It is evident that when this implement was in use, the end nearer to which the groove occurs, was held away from the individual while he was employed shaping the edge of the weapon upon it.

No. 34 is a flat fragment of quartzite six inches and one-fifth long, four inches and one-tenth broad, and one inch thick. It has been artificially formed into an irregular oval shape, the edges of which are rough and fractured. One surface is

pitted over with minute hollows; the other is perfectly flat and smooth, but is not grooved like the last specimen. On this surface, however, with the aid of a lens, faint striations can be detected traversing it in its longest diameter, and from the presence of these I think it is probable that the specimen has been used for the purpose of putting the finishing touches on the fine cutting edges of their stone weapons.

No 37 is a somewhat flat, nearly circular implement formed of quartzite, which has evidently been used for bruising nardoo seed. It is three inches and four-fifths in greatest diameter, and one inch and two-fifths in greatest thickness. Its thickness around the periphery is nearly uniform, but is not so great as in the centre of the implement. One surface, the lower, is flat and slightly polished, due to the friction produced in bruising the seed between it and another flat surface The upper surface is slightly convex, and has not been produced by artificial mechanical means. Except the slightly polished surface above-mentioned, there is no appearance of the present form of the implement having been produced artificially. It has probably been a pebble picked up, because of its convenient shape, which adapts it to the purpose for which it has been used by the Aborigines.

In concluding this paper I may put on record a locality where a rock surface occurs, such as that mentioned above as having been used by the Aborigines for grinding their stone weapons.

While travelling with Mr. Lowe, of Wilbertree, from Home Rule, in the Mudgee District, to the Talbragar River, to visit a deposit containing fossil fish, that gentleman showed me the rock-surface in question. It occurs on the right bank of the Cockabutta Creek, in the Parish of Bobada, County of Bligh. The district consists of extensive outliers of Hawkesbury Sandstone, which locally overlie no great thickness of portion of the Permo-Carboniferous Series, while there are local areas where the older Palæozoic formations crop out through both these newer formations. The Cockabutta Creek, however, at the locality I mention, has merely worn its channel into the Hawkesbury Sandstone, which at this particular spot is exposed for a considerable distance along its banks. There was little or no water in the creek at the time of our visit, which was during the drought of 1888. The sandstone is by no means fine-grained, for in places it is gritty and full of pebbles. Its weathered surface rises gently from the creek-bed, and, for about twenty yards along the banks this surface is dotted over with hundreds of grooves from an inch to an inch and a half in depth and of variable length. About twenty feet higher up the bank another flattish surface of sandstone is exposed, and this presented the same appearance, being hollowed out in innumerable grooves similar to the others, and undoubtedly produced by the Aborgines while grinding an edge on their tomahawks. A number of chips of a hard rock were picked up around these ground surfaces, and these were certainly

not obtained from any rock mass in the immediate neighbourhood, but were probably brought from a distance. It is evident that this locality was a favourite camping-ground of some tribe of Aborigines (probably local), and from the enormous number of grooves present on the rock surfaces, the place must have been visited very frequently. Some of the grooves seemed a great deal more recent than others. The groovings on the higher surface having every appearance of being much older than those near the present creek. It is just possible that the difference of the level between the two sets of grooves may represent the time taken by the creek to erode its channel from the one level to the other, for, according to the reported methods of procedure, the Aborigines did not use a rock surface for the purpose referred to, unless it was in close relation to the water. It was stated to me that the method pursued was as follows:—The water was laved from the creek, generally by the gins, on to the rock surface where the sharpening was to take place, and for this reason these surfaces were always chosen close to the water. It might be suggested that the higher groovings may have been produced at times when the creek was flooded up to that level, but the large number of the grooves in that position is against this idea, because the creek does not drain any large area of country, and, consequently, when in flood would certainly not take more than a few hours to subside. It is probable that some of these grooves are of considerable age, as it is evident that these rock surfaces have been used for a very long time.

XII.—Descriptions of Two undescribed Univalves from the Carboniferous Rocks of New South Wales; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

IN the Annual Report of this Department for 1889,* I gave a list of fossils collected by the Rev. W. H. H. Yarrington, M.A., at Torryburn, a new locality about twelve miles from Paterson, Co. Paterson. The organic remains in question indicate a well-marked horizon in our so-called Lower Carboniferous rocks, and bear a stronger relation to the European Carboniferous Limestone than any I have yet examined from Eastern Australia. Since Mr. Yarrington's collection was made we have been favoured with a second series by Mr. John Waterhouse, M.A., and I am in consequence able to afford a more satisfactory determination of certain species than formerly, and describe two of the Univalves, which are certainly undescribed so far as Australia is concerned.

* Ann. Mus. Hist. Nat. Belgique, 1883, VIII.

The additional species to be added to the list are *Orthotetes crenistria*, Phill, *Strophomena analoga*, Phill., *Productus giganteus*, Martin, of the form called *P. maximus* by M'Coy, and a small *Conularia*.

The species to be described both belong to the Pleurotomariidæ, and to genera new to Australia, viz., *Gosseletia*, and *Baylea*.

Genus Gosseletia, *de Koninck*, 1883.
(Faune Calc. Carb. Belgique, pt. 4, p. 28.)*
Gosseletia australis, *Eth. fil.*

Sp. Char.—Shell sub-globular, heliciform, composed of six, or perhaps seven, convex whorls; spire short, and somewhat depressed; suture moderately apparent, without being deep; body-whorl more than double the height of the remainder of the shell, regularly convex and in no way angular; band very apparent, straight, convex, and prominent, placed at about one-third the height of the whorl from the suture, and not on the greatest periphery, defined by two bounding grooves, both of which appear equally well marked, the lower being the continuation of the suture; base somewhat flattened; callosity large, irregularly semi-lunar, and bounded by a shallow groove; apperture unknown; surface, apparently smooth.

Obs.—I was first made acquainted with this interesting addition to our Carboniferous Fauna by a single example presented by Mr. H. Copeland, M.L.A., from the Isis River, Murrurundi. It is very closely allied to the Belgian Carboniferous Limestone shell *Gosseletia callosa*, De Kon,* the type of the genus. Our shell, however, differs in being a much larger species, the prominence and convexity of the band, besides other general features. We possess the species in all ages, from the young state to maturity.

Genus Baylea, *de Koninck*, 1883.
(Faune Calc. Carb. Belgique, pt. 4, p. 68).
Baylea Koninckii, *Eth. fil.*

Sp. Char.—Shell irregularly turriculated, gradiform, of about six very angular whorls, concave on the sides, horizontal or slightly concave on the upper surface, the angle formed by the union of the two surfaces being rather more than a right angle, occupied by the band, and forming the greatest periphery of the shell; band of medium width, limited on its inner edge by a prominent keel; base convex, separated from the concave side of the body whorl by the first of the spiral ridges ornamenting it; the upper surface and side of each whorl ornamented by from two to three fine spiral ridges; mouth and umbilicus unknown.

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* Faune Calc. Carb. Belgique, pt. 4, p. 28, t. 23, f. 13-16.

Obs.—This species first came under my notice from a N. S. Wales locality in Mr. Yarrington's collection, and other specimens were subsequently forwarded by Mr. Waterhouse. It is obviously near *Baylea Leveillei*, De Kon.,* but is much more turriculated, whilst the marked subdivision of the body-whorl into two areas, distinctly separates our shell from the Belgian. The very turriculated outline would also place *B. Koninckii* near *B. Yvani*, Lev., but there are no other specific characters in common.

In certain Queensland univalves forwarded to me from the Rockhampton District, by Mr. C. W. de Vis, M.A., Curator of the Queensland Museum, which I think may be this species, the concave sides of the body whorls are much less marked, but become apparent in the casts. At present I believe them to be the same species.

* *Loc. cit.* p. 73, t. 27, f. 6-10.

PLATE III.

Fig. 1. Horizontal section of Raised-beach beds at Largs, near East Maitland.

Pleistocene { 1. Raised-beach.
2. Ancient flood-loam capping preceding.

Recent...... { 3*a*. Recent dark-grey clay.
3*b*. Recent sandy-clay and loam.

Fig. 2. Horizontal section of Raised-beach beds from Knott's Well to West Maitland Waterworks.

Pleistocene { 1. Raised-beach.
2. Ancient flood-loam capping preceding.

Recent.........3. Recent fluviatile clay, sand, and gravel.

Permo-Carboniferous...Pp. 3. Upper Marine Series, composed of pebbly-sandstones, and mud-stones.

The scales are shown on the face of the plate.

11*a* 306—90

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

ERRATUM.

Vol. II, Pt. 2, p. 58, line 51—
FOR (*Ostrea cuculata*), READ *Ostrea edulis*, Linn., var *Angasi*, Sowb.

source of the gold. I entrusted the microscopical examination of these rocks to my able Colleagues, Messrs. T. W. Edgeworth David, B.A., F.G.S., and W. Anderson, Geological Surveyors, and the results of their investigation are recorded in the following paper.

The conclusions arrived at afford important information regarding the nature of the auriferous formations of which Mount Morgan is composed, and while they throw some light upon the probable origin and extent of the payable ore deposits, it is evident that further investigation is required for the elucidation of the subject.

The suggestion of Mr. R. L. Jack, F.G.S., Government Geologist of Queensland, that the auriferous deposit is of geyser origin, is supported in regard to the deposition of the gold and its siliceous and ferruginous matrix from thermal aqueous solution; but it appears that the deposit accumulated in fissures and cavities in the rocks, rather than as an overflow from the usual funnel-shaped geyser-crater.

Mount Morgan consists of highly metamorphosed sedimentary rocks, chiefly "greywacke," as Mr. Jack has termed them, which, from the fossils found in the neighbourhood, the Palæontologist, Mr. R. Etheridge, Junr., considers to be of Permo-Carboniferous age. These rocks contain auriferous iron pyrites, disseminated more or less through them—in one instance a mass of pyrites with a little silica was met with over one hundred feet in diameter—and have been intruded by dykes of hornblendic granite and porphyritic dolerite. The intrusion of the granite was probably the older, and induced the formation of the pyrites, and the siliceous induration of the argillaceous strata. Subsequently, as water passed through the jointed pyritous strata near the intrusive dolerite dykes, chemical action set in, kaolinising the dolerite and oxidising the pyrites, the gold in the latter being dissolved, possibly as sulphide, and re-deposited by itself, or with iron oxide, as the solution passed through the fissures and cavities in the rocks. Apart from the kaolinisation of the dolerite, the cavernous quartzite deprived of the pyrites which its cavities once contained, and the deposition of siliceous sinter and of hydrous iron oxide with gold, there is also evidence of chemical reaction in the aluminous rocks being highly charged with sulphate of alumina, and in the large and small yellow segregated masses of basic sulphate of iron. The latter has yielded on analysis by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department, as much as 24·419 per cent. of sulphuric anhydride, and might possibly be hereafter utilised in the manufacture of sulphuric acid.

Until further observations have been made no definite conclusion can be formed as to the source of the gold; but in my opinion the evidence so far tends to show that the gold has been derived in the manner above stated, and that the heat generated by the kaolinization of the dolerite may have largely contributed to the effects produced. If so, the payable gold-bearing ore will be found as hitherto, chiefly within the region which has been affected by the decomposition of the dolerite. The intrusion of the dolerite dykes was probably the cause of the fracturing of the strata, and it appeared to me that the principal line of disturbance is the fissure filled in with ferruginous lode stuff which was cut through in the Freehold Tunnel; the other fissures in the Mount may be connected with this, such as the small ones containing the rich gossan which has been worked at the summit. The water which first set up the chemical changes in the pyritous strata and dolerite may have permeated the fissured strata by infiltration from the surface; or it may have come up as thermal water containing gold, &c., in solution, as Mr. Jack has suggested, through a fissure or pipe from below. Even should the latter have been the chief source of the gold, yet the gold derived from the decomposition of the pyrites must have considerably enriched the deposit. I am of opinion that the payable ore is confined to the region which has been thus affected or oxidized, and that the extent of the ore can be proved by sinking in or

near the Freehold Tunnel lode, close to the kaolin dyke, and driving on either side until the undecomposed pyritous rocks be met with. The principal gold-bearing deposits will, I think, be found in the vicinity of the kaolin dyke descending not vertically, but diagonally along the line of dyke in a south-easterly direction. From the examination of the rocks microscopically, Messrs. David and Anderson believe that the intrusions of dolerite are of two ages.

It is highly important that as the mine works extend, the different varieties of rock met with should be collected, and their petrological characters determined; for such investigations will prove of considerable value in connection with the discoveries of similar deposits in other localities.

The occurrence of gold that has evidently been deposited from an aqueous solution is not uncommon elsewhere; but the remarkable association of the different rocks in Mount Morgan has not as yet been observed in New South Wales.

The Mount Morgan Mine, therefore, both as regards the great extent and mode of occurrence of its rich auriferous deposits, may be recorded as unique in the history of gold mining. The natural purity, or high quality of the gold, also has been stated by Dr. A. Leibius, M.A., F.G.S., Assayer to the Royal Mint, Sydney, to be unequalled by that of any other gold hitherto found.

II.—Notes.

The rocks and minerals may be ranged in four groups:—

1. SEDIMENTARY, WITH INTERBEDDED VOLCANIC ROCKS.

   (*a*) Quartzose argillite, an altered mudstone called "greywacke" in Mr. R. L. Jack's Report. This rock passes, in places, as near the Freehold Tunnel, Mount Morgan, into a red jasperoid claystone. Slides Nos. 26 and 27.

   (*b*) Highly-silicated quartz-felsite, interbedded with the preceding rock. Slide No. 48.

   (*c*) Secondary rocks, aluminous, quartzose, or ferruginous, formed from the decomposition of these Palæozoic sedimentary rocks. These secondary rocks constitute part of what Mr. R. L. Jack terms the "overflow deposit." There is no certain evidence, however, among the specimens in this collection, of the occurrence of a distinct rock species forming the so-called "overflow deposit," whose formation seems to have been largely the result of the decomposition, and subsequent molecular replacement of the minerals of the various rocks *in situ*, as is the case with those parts of the "overflow deposit" which are on the lines of the dolerite dykes. Slides Nos. 28 and 29.

2. HORNBLENDIC GRANITE, occurring in dykes about five chains north-west of Callan's Knob. Slides, 30, 31, 32, 33.

3. (*a*). ANDESITIC DOLERITES, occurring principally in dykes, which intersect the "greywacke."

    (i) Dolerite, rich in augite, *e.g.*, Slide 34, from near Telegraph Office, Mount Morgan, and Slides 35 and 36, from Freehold Tunnel, Mount Morgan.

    (ii) Dolerite, porphyritic by triclinic felspar. Slides 37, 38, 39, 40, 41, and 46.

   (*b*) Secondary rocks formed from the decomposition *in situ* of the dolerites, as the Kaolinite dykes at the summit of Mount Morgan, and certain portions of the "overflow deposit," on the line of the dykes, which are undoubtedly portions of the latter decomposed *in situ*. Slides Nos. 42, 45, and 47 (*a*, *b*, *c*).

4. SECONDARY ROCKS, including veinstones, formed of material transported by thermal waters, and derived chiefly from the rocks of 1 (*c*) and 3 (*b*). To this formation belong the spongy quartz and such aluminous and ferruginous portions of the "overflow deposit" as show evidence of having been transported. The auriferous spongy ferruginous quartz, and enclosed lumps of tubulated kaolin of Mount Morgan proper, as well as the undecomposed pyritous veinstones, probably also belong to this formation. Slides Nos. 43 and 44.

III.—Detailed description of the above-mentioned rocks.

1. SEDIMENTARY WITH INTERBEDDED VOLCANIC ROCKS.

   (*a*) Quartzose argillite from right bank of River Dee, about eight chains below the junction of Mundic Creek.

   This is a hard dark grey to greenish black, fine grained rock, irregularly jointed.

Slide No. 26, is from the Machine Site Dam, and consists of a felspathic base containing viridite and a little bluish-green chlorite with a sprinkling of macroscopic fragments of angular quartz.

Slide No. 41 may perhaps in part be from this rock altered at its contact with the dolerite dyke, which runs through the northern end of Portion 3.

Slide No. 27 is from the creek in Portion 4. It is a greenish-coloured, compact, fragmental rock resembling somewhat a volcanic tuff, consisting of a brownish-grey base of felspathic material and epidote, and containing microporphyritic abraded, or corroded fragments of quartz and felspar crystals with numerous opaque aggregations of magnetic iron. This rock is similar to No. 26.

   (*b*) Highly silicated quartz-felsite interbedded with the "greywackes".

Slide No. 48 is from Mount Morgan Town, near the granitic and doleritic dykes. This is a light-grey coloured siliceous looking rock, full of macroscopic quartz crystals. Microscopically, it is made up largely of secondary quartz grains; but among these grains there is still a network of the original felsitic base. There are a few porphyritic felspars present, but the chief prophyritic ingredient is quartz, which although somewhat corroded still show crystalline edges and angles and contain included portions of the base.

(*c*) Secondary Rocks resulting from the decomposition of the Palæozoic sedimentary rocks.

Slide No. 28 is from tunnel on east side of Mount Morgan, about 250 feet from the top. This is a greenish-grey rock known as the "Mottled Rock." It consists of a translucent base of felsitic material with masses of secondary quartz and circular aggregations of microscopic crystals of iron pyrites, together with some macroscopic iron pyrites. This rock is a trifle more siliceous than No. 29 to judge from its hardness. It has probably been formed from the alteration either of the dolerite or of the fragmental Palæozoic rocks, but more probably the latter.

Slide No. 29 is also "Mottled Rock" from Mount Morgan. It is similar to No. 28 with the exception that it is more felspathic and consequently not so hard. It is also probably an alteration of the Palæozoic fragmental rocks.

2. HORNBLENDIC GRANITE. (Nos. 30, 31, 32, 33.)

Slide No. 30 was taken from a dyke near Callan's Knob. It is a crystalline-granular granite consisting of triclinic felspar, some orthoclase and mica, hornblende and quartz.

Slide No. 31 cut from a specimen collected from the front of the Telegraph Office, Mount Morgan, is a granite composed chiefly of quartz and felspar with a little hornblende and opacite. The felspar and hornblende are much decomposed. Possibly this may belong to the same eruptive mass as that from which Slide No. 30 was taken.

Slide No. 32 from top of a hill, base of Desert Sandstone, from a shaft on the side of Mount Ballad, is a granular crystalline rock composed of triclinic felspar, hornblende (primary), a little chlorite resulting from the decomposition of hornblende, opacite, and a little quartz. This is a quartz diorite resembling No. 30, with the exception that it contains far less quartz and no mica. It probably, however, belongs to the same intrusive rock-mass as Nos. 30 and 31.

Slide No. 33 is from the shaft of the Dee Prospecting Company, Mount Morgan, at a depth of three-hundred and seventy feet. This is a somewhat fine-grained greenish rock, very full of iron pyrites. It is considerably decomposed, and consists

chiefly of quartz and orthoclase felspar with hornblende and a green decomposition product of hornblende. Iron pyrites is very abundant in the rock, probably as a secondary constituent. This rock is similar to Nos. 30, 31, 32, but contains more quartz than No. 32.

3a.—ANDESITIC DOLERITES.

(i) *Dolerites rich in augite.*

Slide No. 34 is from near the Telegraph Office, Mount Morgan. It is a light grey-coloured crystalline rock, containing macroscopic iron pyrites. Microscopically it is seen to be a crystalline granular dolerite without olivine, composed of triclinic felspar, augite, and magnetite, with a little chlorite and epidote. It shows little decomposition, and the augites, which are porphyritic, are very fresh and abundant.

Slide No. 35 is from the Freehold Tunnel, east of the lode. This is a compact fine-grained, grey-coloured rock. It is micro-crystalline in structure, and is composed of lath-shaped triclinic felspar, augite, and irregular patches of a black opaque mineral, probably magnetite, some smaller crystals, which are magnetite, and a large proportion of epidote. This rock is a diabasic dolerite, and from the abundance of augite present may be classed with No. 34.

Slide No. 36 is from the south-west spur of the Sugar Loaf, Mount Morgan, and is a grey-coloured crystalline granular rock composed chiefly of triclinic felspar, augite, magnetite, and a green decomposition product (serpentine), and a little free quartz, probably secondary. This rock may possibly belong to the same eruptive mass as No. 32.

(ii) *Dolerites porphyritic by triclinic felspar.*

Slide No. 37 is from tunnel in Portion 3. It is a light grey coloured rock, spotted over with the fractured faces of the large porphyritic felspars. The rock, which Mr. R. L. Jack classed provisionally as a rhyolite, basing his determination on such evidence as was available for him in the field, proves upon subsequent microscopic examination to be a diabasic dolerite, porphyritic by triclinic felspar, with an occasional porphyritic crystal of augite. It consists of a base of triclinic felspar, magnetite, and augite, with porphyritic crystals of triclinic felspar, showing well marked zonal structure, a little undecomposed pyroxene, and a large proportion of greenish decomposition products.

Slide No. 38 is from Portion 95, Sunbeam Tunnel, Mount Morgan. This is a diabasic dolerite resembling No. 37. It consists of a micro-crystalline base of lath-shaped felspars, augite and magnetite with greenish decomposition products, and porphyritic crystals of triclinic felspar and micro-porphyritic crystals of augite. The base of this rock is very finely crystalline, and shows basaltic structure.

Slide No. 39 is from Portion 95, Sunbeam Tunnel, Mount Morgan, and is evidently the same rock as No. 38, a diabasic dolerite. It is a little more decomposed, and more coarsely crystalline in the base than No. 38.

Slide No. 40 is from the Mundic Reef Shaft, Mount Morgan. This is a light grey finely crystalline rock, consisting of triclinic felspar, augite, greenish decomposition products and a little magnetite, with porphyritic crystals of triclinic felspar. This is certainly an igneous rock and belongs to the diabasic dolerites.

Slide No. 41 is from tunnel on Portion 3, Mount Morgan, and is a fine-grained compact dark-coloured rock containing iron pyrites. It is much decomposed and may be classed as a diabasic anamesite. It consists of a micro-crystalline mass of lath-shaped triclinic felspars with abundant magnetite, various greenish minerals, some of which are chlorite, resulting from the decomposition probably of augite, and a little decomposing augite with a sprinkling of angular primary quartz, perhaps derived from the "greywacke."

Slide No. 46 is from a depth of five hundred and sixty feet in the diamond drill bore at Mount Morgan. The rock is a diabasic anamesite, and may be classed with No. 41. It contains a good deal of free quartz, but consists chiefly of a base formed of triclinic felspars and much decomposed augites, with magnetite and iron pyrites. The porphyritic minerals are triclinic felspars, some of which are quite fresh, the majority, however, being much clouded, and a light-green mineral which is undoubtedly decomposed augite, some portions of the crystals still being fresh, brown-coloured, and pleochroic. In some cases the larger quartzes seem, from the abundance of inclusions, to be primary in their origin, while most of the interstitial quartz in the base is certainly of secondary origin due to infiltration.

3*b*.—SECONDARY ROCKS FORMED FROM THE DECOMPOSITION OF THE DOLERITES.

Slide No. 42 is from (A), on Jack's plan of Mount Morgan. Macroscopically, this rock can be distinctly seen to be a decomposed and kaolinised form of the diabasic dolerites which are porphyritic by felspar. It consists of a micro-crystalline base of kaolinised felspar, ferrite, and limonite with porphyritic crystals of kaolinised triclinic felspar. Most of the kaolinised porphyritic felspar crystals are surrounded by cracks which radiate from them into the base, where they die out. These cracks may probably be due to the expansion of the individual crystal of felspar during its kaolinisation. This rock is no doubt a decomposed form of Nos. 37, 38, or 39.

Slide No. 45 is from the south-west spur of the Sugar Loaf, on road near Dee River, Mount Morgan. This is a white kaolin rock. The section shows well-defined somewhat angular areas, scattered through it. These have all the appearance of kaolinised felspar crystals, and they no doubt represent the

porphyritic felspar crystals of the unaltered rock, which in this case was unmistakably a diabasic dolerite similar to Nos. 37, 38, and 39, if not identical with the latter two.

Slides No. 47, *a, b, c,* are from the west side of Mount Morgan. They are light-brown finely-speckled rocks, chiefly composed of kaolin with fine siliceous veins traversing them, and small irregular areas of decomposition filled with secondary quartz, there is a considerable quantity of a black opaque iron compound present. Although the evidences of the presence of the decomposed porphyritic felspars are not so apparent as in the case of Nos. 42 and 45, still there is little doubt but that this kaolinite has resulted from the decomposition and alteration of one of the andesitic dolerites.

4. SECONDARY ROCKS.—Including vein-stones, formed of material transported by thermal water, and derived chiefly from the rocks of 1 (c) and 3 (b).

Slide No. 43 is from Portion 95, Sunbeam Tunnel, Mount Morgan, and is a greenish-coloured compact siliceous-looking rock containing a great deal of macroscopic pyrites. Microsopically it consists principally of mosaics of secondary quartz with fragments of primary quartz, abundant crystalline aggregates of secondary pyrites and serpentinous material. This rock has probably resulted from the alteration of serpentine or, possibly, from the diabasic dolerites into a siliceous rock, the silica having largely replaced the original constituents.

Slide No. 44 is from the east side of the lode in the Freehold Tunnel, Mount Morgan. This rock is a pyritous serpentine consisting of a serpentinous translucent base, through which are distributed macroscopic and microscopic crystals of iron pyrites in great abundance, and great numbers of microscopic crystals, which, judging from their geniculate twinning, are very probably rutile. Macroscopic enclosures of a rock which may probably be either fragmental or doleritic occur at intervals. This rock is so largely impregnated with secondary pyrites as to leave its original nature a mere matter of conjecture.

IV.—Conclusions.

The conclusions that seem to follow from the microscopical study of this collection of rock specimens from Mount Morgan may be summed up thus:—

That all the rocks in the immediate neighbourhood of Mount Morgan proper, and the other isolated centres from which hot siliceous waters or vapours emanated, have been very much altered.

That the Palaeozoic rocks of the district have been intruded by irregular masses of granite and dykes of dolerite.

That the dolerite dykes are probably of two ages. Some of them are allied to the granites and are probably of the same age, while others of them were probably a distinct eruption.

That the activity of the geysers which produced the alterations in the rocks was subsequent to the intrusion of these eruptive rocks.

That the so-called overflow deposit is not really a surface deposit, but has been largely formed of the various rocks altered *in situ.*

That this alteration has been brought about in the vicinity of the pipes of the geysers, at all depths from the original surface downwards, where considerable areas of the rocks through which the pipes passed have undergone a process of digestion in the hot silicified waters or vapours which soaked away from these pipes as a centre. On the cessation of the activity of the geysers, the place of the minerals which had been decomposed out of the various rocks, would be occupied by the deposition of silica from the cooling waters.

That wherever the dolerite dykes are present in this area, which has been saturated with the siliceous waters, they have been more or less altered into kaolinite.

XIV.—Laboratory Notes on some New South Wales Minerals: by J. C. H. MINGAYE, F.C.S., Analyst and Assayer.

Note I.—A Mineral resembling Tasmanite.

A greyish coloured shale, somewhat resembling Tasmanite in appearance, from Gunnedah, on being submitted to a proximate analysis, yielded as follows:—

Hygroscopic moisture	1·35
Volatile hydrocarbons	32·18
Fixed carbon	3·61
Ash	62·83
	100·00

Specific gravity—1·755.

Sulphur in shale—1·208 per cent.

No true coke formed, a dark powder being left. Ash—reddish tinge, dense.

Under the microscope a section of the shale had the appearance of consisting of a number of seed-like spores, and large pieces of stone, containing pyrites, were also visible. On heating, the mineral evolved sulphurous acid, and on ignition gave

off a smoky fetid smell. It was acted upon to some extent by alcohol, ether, and carbon-bisulphide, the extract haviug a yellowish resinous appearance. On distillation it yielded a heavy oil and solid product, having a very disagreeable odour.

This mineral, though somewhat resembling Tasmanite, is shown by its insolubility in alcohol, ether, and carbon bisulphide not to differ from the resiniferous shale described* by Professor Church, who states that it is not dissolved in the least degree by alcohol, ether, &c.

It is evidently worthy of a more detailed examination, and an ultimate analysis would be of value, which I am sorry to say could not be performed, as the amount of it at my disposal was small. I hope shortly to obtain sufficient to make an analysis, and also an examination of the oils and solid products.

Note II.—On the occurrence of Platinum "in situ" in N. S. Wales.

A sample of tailings and slimes obtained from a mine in the Orange District, by Smith and Party, was submitted for assay by the ordinary method, *i.e.*, fusion and cupellation, when it was noticed that the gold buttons contained some foreign metal. An examination being made detected the presence of small quantities of Platinum. The slimes yielded 2 dwt. per ton, the tailings much less. Platinum was also found in some ferruginous felspathic rock with magnetite, obtained from Surface Hill, Wollombi; the sample of stone sent, however, being small, an estimation could not be made until a larger sample was supplied.

The occurence of Platinum "in situ" in a felspathic lode material in the Broken Hill District has been previously pointed out by me in the Annual Report of the Department of Mines, 1889, p. 240, and in a paper read before the Royal Society of N. S. Wales, November 6th, 1889.

Note III.—Analysis of a Water taken from a Hot Spring, Yarrangobilly Caves.

Total solid matter, 9·044 grains per gallon.

Analysis.	Grains per gallon.
Carbonate of lime	6·552
Carbonate of magnesia	nil
Silica	·868
Alumina	trace
Chloride of sodium	1·318
Strong trace of strontia, nitrates, and undetermined...	·306
	9·044
Free ammonia	nil.
Organic or albummoid do	·026 per million parts.
Chlorine	·8 grains per gallon.

Water free from odour, clear. An excellent description of spring water.

* Phil. Mag, 1864, xxviii, p. 465.

XV.—On the Occurrence of Microscopic Fungi, allied to the Genus *Palæachlya*, Duncan, in the Permo-Carboniferous Rocks of N. S. Wales and Queensland: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate VII.]

IN 1876 Prof. P. M. Duncan, F.R.S., described certain microscopic bodies penetrating the shells of Silurian and Devonian Brachiopoda, and the tissue of Tertiary Corals.* To these the author applied the name of *Palæachlya perforans*, regarding the organism as an endophytic unicellular alga, allied to the living *Achlya*.

Previous to Duncan's researches, similar bodies, he tells us, had been studied by the late Prof. Quekett, the late Dr. W. B. Carpenter, A. W. Kollicker, and C. Wedl, and references were made to their writings. Quekett and Wedl considered the endophytes to be confervoid algæ, Kollicker as parasitic fungi, and Wedl even going so far as to refer them to the existing *Saprolegnia ferax*, Kützning. Then, says Dr. Duncan, "these investigations showed that there were parasitic vegetable growths in modern corals, and in many shells, even as old as the Devonian, and that they were either confervæ or fungi."

Whilst studying the microscopic structure of Monticuliporoid corals from the Permo-Carboniferous of N. S. Wales and Queensland, my attention was attracted to some spicular-looking hollow tubes on the one hand, within the corallites of *Stenopora crinita*; and meandering perforating tubes in the corallum of another Monticuliporoid on the other—in both cases clearly no part of the respective organisms themselves.

Before proceeding to describe the Australian forms, it is necessary for the proper understanding of their structure, to give an epitome of that of *Palæachlya perforans*, as described by Duncan.

In the Tertiary corals examined by the latter, the canals branch and end in *culs de sac*, possess dark borders, and a refractive central area. In the Silurian coral *Goniophyllum pyramidale* the tubes or canals have no proper wall, but are simply excavated out of the coral substance. They occur either just beneath the surface, parallel to it, or pass inwards at different angles, with an average diameter of 0·008 inches, and are usually straight, although sometimes branching, the calibre

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* On some Unicellular Algæ parasitic within Silurian and Tertiary Corals, with a Notice of their Presence in *Calceola* and other Fossils.—*Quart. Journ. Geol. Soc.*, 1876, XXXII, p. 205.

differing but little either in a parent tube or its branches. Both are usually filled with a dark granular matter, except in the middle line, thus giving rise to dark edges and a clear centre. As a rule the tubes have no definite origin or ending, but at times they terminate in *culs de sac*, as in the case mentioned above. In other instances, the tubes arise from dark spots, larger than their diameter, filled with a mass of globules; or, dark globular pigment masses are in contact with one end, and are either much crowded* or arranged in disconnected linear series†. The globules are probably the remains of resting spores, and the pigment masses of conidia. In the section of *Calceola* some of the larger tubes end at the surface in a loculus‡ crowded with spores, having a black globular appearance.

Such is the general appearance presented by the bodies described by Professor Duncan. The Australian forms will now be described, then their analogy pointed out, and finally their relations to living forms discussed. It will be most convenient to describe the Queensland fossil first, as its structure approaches nearest to that of *Palæachlya perforans*.

The entire corallum of the Monticuliporoid, so far as preserved, is thickly permeated with very minute tubes in all directions (Pl. VII, Fig. 1), parallel to the direction of growth of the corallites, transverse to the same, or at an oblique angle. These tubes are flexuous in habit, circular in section (Pl. VII, Fig. 1), and with their terminations, when seen, irregularly enlarged, and there are occasional enlargements in the course of a tube. There also appears at times to be a dichotomization, a tube subdividing into two branches. The different directions in which the tubes permeate the corallum renders it impossible to figure the course of a tube for any extent of its length, but a fairly good idea may be obtained from Pl. VII, Fig. 1. There appears to be a definite wall represented by a line of darker colour on each side of a tube's course, the centre being either refractive, or filled with granular matter, finely divided, of a uniform dark sherry-yellow. In only one instance have I seen any trace of spores, and these partake of the same character as those presently to be described in the form from New South Wales, round globular black bodies. It is proposed to call this perforating form of the Queensland Permo-Carboniferous *Palæachlya tortuosa*, in allusion to the very irregular and winding course of the tubes. With the exception of Duncan's figures, I have only met with one illustration of a similar organism, that given by Messrs. Wagen & Wentzel, who figure§ it permeating the tissue of *Geinitzella columnaris*, Schlotheim, sp., from the Cephalopoda bed of the Upper Productus Limestone of Chedru, Salt Range, India. It is exceedingly like the Australian form, but whether identical or not, it is difficult to say.

* Duncan, *Loc. cit.*, t. 16, f. 3, 5.
† Duncan, *Loc. cit.*, t. 16, f. 8.
‡ Duncan, *Loc. cit.*, t 16, f. 12 and 13.
§ Pal. Indica, Ser. xiii., Salt Range Fossils, 1886, I, Pt. 6, t. 115, f. 1.

The bodies discovered in the calices of *Stenopora crinita*, Lonsd., differ much from those just described, both in form and habit. They are straight, tubular organisms, tapering to an acute and apparently closed distal end, whilst the proximal is inflated into a globular chamber, the whole organism having much the appearance of a pin, (Pl. VII., Fig. 2), or, to speak more precisely, the spicules of the sponge, *Axinella*, Hinde.* It is proposed to apply to these the name of *Palæoperone*† *endophytica.* They occur in matted clusters and small irregularly-arranged bundles, and although more or less variably placed as regards one another, are usually sub-parallel to the direction of the corallites. In a few instances the tubes have been seen across the corallite containing them, but there is no evidence that the corallite wall is ever pierced. In this position their hollow condition becomes apparent, and also the presence of a proper wall, shown by a dark encompassing line, and they are generally filled with an amber-yellow colouring matter. In one instance, however, the proximal end of the tube is occupied by five round spore-like bodies (Pl. VII., Fig. 3) in linear series of a black colour. These are probable spores, and in that case the spicular tubes would represent sporangia, of course assuming the former to be in place. The contiguous tube to that just referred to presents a similar space to that occupied by the five spores, but devoid of such, or even the yellowish colouring matter, and its appearance suggests the former presence of spores, which had possibly swarmed (Pl. VII., Fig. 3). In a third case, the distal portion of a spicular tube is filled with a dark homogenous colouring-matter, the middle portion is clear, whilst at the proximal end occurs a cluster of spores, quite similar to some of Professor Duncan's figures of *Palæachlya perforans*,‡ and possibly in the act of swarming. The only other departure from the infilling of amber-yellow colouring-matter, occurs in the larger portion of some of the tubes when filled with a dense black deposit. The proximal distentions of the tubes, taking the place of the pin-heads, to carry out the simile, differ from those of *Palæachlya* in that they are terminal, and not irregularly placed along the course of the tube. The two forms further disagree in the irregular course pursued by the one, and the brief and rigid length of the other, sometimes, but not often, very slightly curved.

I now come to a very interesting point in this investigation—the nature of the black masses infilling a few of the spicular tubes. A number of the corallites of *Stenopora crinita* in the immediate neighbourhood of the endophyte, are more or less filled with an identical black deposit, the partial infilling usually taking the form of a lining along the corallite walls. When in the latter condition these masses gradually become disintegrated towards their inner margins, and dissolve into a multitude of minute densely black opaque globules, of variable size, similar in appearance to the five (Pl. VII, Fig. 3) occupying the proximal end of one of the

* Mon. Brit. Foss. Sponges, Pal. Soc., 1888, Pt. 2, p. 145.
† ἡ περόνη, a pin.
‡ *Loc. cit.* t. 16, f. 12 and 13.

spicular tubes, or sporangia, and previously spoken of as spores. In some instances these globules are loosely aggregated in the corallites, and in either of these conditions are presumed to represent spores which have swarmed. The identity of those massed in the corallites of the *Stenopora*, with those at the proximal end of the sporangium (Pl. VII, Fig. 8), seems affirmed by their respective form, size, opacity, and general appearance. I have submitted these globular masses to a very careful examination in company with my Colleague, Mr. T. W. E. David, B.A., and we have come to the conclusion that the present condition of the globules is that of iron pyrites. If we suppose the original spores to have assumed the properties of a hydro-carbon, apparently the composition of cryptogamic spores during Palæozoic times—these coming in contact with sulphate of iron in solution, an interchange would result in the formation of carbonate of iron, and elimination of sulphuretted hydrogen. A replacement of the carbon by sulphur would produce the desired iron pyrites. One point is certain, the black globular bodies do not occur in the matrix, external to the *Stenopora* tubes, and thereby form one of its constituents.

It is almost needless to repeat the observation that the two forms here described differ much in appearance and habit, and it is only the Queensland fossil which is definitely allied to Duncan's *Palæachlya*. For my own part, I am content to accept his views of the affinity of that fossil, and to adopt them for that here called *Palæachlya tortuosa*, without further discussion. As regards *Palæoperone endophytica*, however, the affinities are not so clear, but I would tentatively call attention to its general resemblance to the Saprolegnean group of Fungi. According to De Bary,* "The genera Saprolegnia, Achlya, and Dictyuchus, when well developed have club-shaped sporangia, the protoplasm of which divides into numerous spores arranged in many rows. Very feeble specimens form only one row of spores, and there is scarcely ever more than one row in the long narrowly cylindrical sporangia of Aphanomyces." When discharged the spores become collected at the mouth of the sporangium in little groups, from which they afterwards burst to swarm. This is excellently shown in a figure of *Achlya*, given by De Bary †; and another by Van Teighem.‡ The larger number of the Saprolegniæ live in water, on animal or vegetable matter, during decomposition, and in liquids charged with organic substances. Le Maout and Decaisne § give a series of figures of *Saprolegnia ferax* in different states of development from the fungus in the form of radiating hyaline filaments covering a dead fly, to the process of swarming of the spores. In their figures the proximal ends of the filaments, forming sporangia, contain numerous granules, or spores, shut off from the remainder of the filament by a septum.

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* Comparitive Morphology and Biology of the Fungi, Mycetozoa, and Bacteria, by A. de Bary (English Edition, by Garnsey and Balfour, 8vo. Oxford, 1887), p. 143.
† *Loc. cit.* p. 143, f. 70.
‡ Traité de Botanique, 1884, p. 1025, f. 618.
§ Traité generale de Botanique, Descriptive et Analytique, 1876, p. 716.

The supposed spicule-like sporangia (Pl. VII., Figs. 2 & 3), it is quite clear, have no connection with the coral *Stenopora*, nor are they the spicules of a sponge, notwithstanding that the simulated appearance of some forms of the latter is striking. A close resemblance exists between the pin-like sporangia of *Palæoperone endophytica*, and the globular-headed gonidiophores of *Phycomyces nitens*,* a terrestrial fungus of the group Mucorini; and a similar organ is developed by *Saprolegnia dioica*.† The single row of spores seen in Pl. VII., Fig. 3, would correspond to the "very feeble specimens" of the genera mentioned by De Bary, whilst in Pl. VII, Fig. 2, we have the spores discharged from the sporangium in a somewhat similar manner to that exemplified in De Bary and Van Teighem's figures of *Achlya*.

The views here enunciated, are so tentatively, with the view of drawing attention to this very interesting fossil, but if a more satisfactory solution of its affinities can be suggested, the Author will be prepared to accept them.

It may not be out of place to state, in conclusion, that several other instances of Palæozoic Fungi are on record. For instance, the late Messrs. Hancock and Athey in their paper, "On some curious Fossil Fungi from the Black Shale of the Northumberland Coal-field," described‡ under the name of *Archagaricon* lenticular bodies with tubular ramifications, and therefore quite unlike even our Queensland form. On the other hand, *Peronosporites antiquarius*, Wn. Smith§, possesses globular oogonia or sporangia supported on distinct threads. It is one of the Saprolegnieæ occurring in the British Coal Measures, and is probably closely allied to *Palæachlya*. Mr. Worthington G. Smith also describes another sporangium of a Fungus from the Coal Measures as *Protomycites protogenes*,¶ but less is known of this than the former.

It is unnecessary to refer to the genus *Traquaria*, Carruthers,‖ as this has been shown** by Prof. W. C. Williamson to be probably a cryptogamic macrospore; nor to the peculiar bodies figured by the last-named author as conceptacles [*Sporocarpon*, *Zygosporites*, *Calcisphæra* and *Oidospora*,],†† as although they are low forms of animal or vegetable life, they are not regarded as of a fungoid nature.

* De Bary, *Loc. cit.*, p. 146, f. 71.

† Le Maout and Decaisne, *Loc. cit.*, p. 716, fig.

‡ Ann. Mag. Nat. Hist., 1869, iv., p. 226.

§ Diseases of Field and Garden Crops, chiefly such as are caused by Fungi, 1884, p. 332, f. 139.

¶ *Ibid*, p. 333, f. 140.

‖ Brit. Assoc. Report for 1872 [1873], p. 126.

** Phil. Trans. R. Soc. for 1880 [1881], clxxi, p. 511.

†† Phil. Trans. R. Soc. for 1878 [1879], clxix, Pt. 2, p. 357; *Ibid* for 1880 [1881], clxxi, Pt. 2, p. 507.

XVI.—The Associated Minerals and Volatility of Gold: by T. W. EDGEWORTH DAVID, B.A., Geological Surveyor.

I.—Introduction.

THROUGH the kindness of Dr. J. Storer and Dr. S. P. Mackenzie, copies have been lately supplied to me of three papers recently read before the American Institute of Mining Engineers, on subjects of such immediate importance to mining and metallurgy in this Colony, that I feel justified in inviting attention to the new trains of thought suggested by these papers.

II.—W. M. Courtis on Gold Quartz.

The first on "Gold Quartz," by W. M. Courtis,* treats of the distinguishing microscopical characteristics of respectively good and poor gold-bearing quartz. While admitting that the evidence so far collected by him is not finally conclusive, Mr. Courtis argues that as a rule good gold quartz contains far more microscopic fluid enclosures and cavities than barren quartz, and in the former such enclosures show a tolerably uniform parallellism of arrangement, whereas in the latter they are somewhat irregularly distributed.

III.—Collateral Evidence.

The fact has long been known to geologists that liquid carbonic acid gas is present in globules of microscopic size in the quartz of granite, and also in that of many veinstones, and as it is known by laboratory experiments that a pressure equal to forty atmospheres (about three hundred and fifty tons per square yard) is necessary for converting carbonic acid gas into a liquid state, this is often quoted as a proof of the great pressure under which such granites and veinstones must have been formed. It is not only, however, in the form of carbonic acid gas (carbon-dioxide) that carbon has been proved by petrologists to be present in metalliferous veins, but also as graphite and anthracite. The colouring matter of fluor spar and of smoky quartz has also been attributed to carbon in some form, though in the case of the latter mineral the smokiness of the quartz is thought by some to be due to the presence of titanic acid, such quartz usually containing numbers of needle-shaped crystals of that mineral. That carbon is present as a deep-seated mineral at certain localities, where quartz veins are even now in process of formation, is proved by its abundant discharge at some volcanic vents and solfataras. The Author of the paper above referred to on gold quartz has detected the presence of liquid carbonic acid in many of the gold-bearing quartz-veinstones of Calaveras County, California.

* Trans. American Inst, Mining Engineers. Gold Quartz. By W M. Courtis, Detroit, Mich. (Ottawa Meeting, October, 1889).

The presence of liquid carbonic acid in some quantity in the rich parts of the gold-bearing quartz veins above mentioned is obviously of great interest taken in consideration with the well-known influence of carbon in precipitating gold in a metallic form from solution. As far back as 1866, Mr. C. S. Wilkinson, F.G.S.,* demonstrated by practical experiment that the introduction of a piece of wood into a solution of chloride of gold brought about a precipitation of the gold in a metallic form; and, later on, Mr. J. Cosmo Newbery B. Sc.† discovered that gold was actually present in minute quantities in the interior of some of the props, which had been standing for many years, partly immersed in the water draining from various gold-mines in Victoria. Some recent researches, on the other hand, by Mr. C. S. Wilkinson, upon wood, which had been standing for some time in the water draining from the Mount Morgan gold-mine, showed that even traces of gold were absent. The timber, however, tested had been standing in the mine for only about twelve months.

The property of wood, or rather of the carbon contained in it, to precipitate gold in a metallic form has been taken advantage of in the Newbery-Vautin Process for the extraction of gold by chlorination, the gold in the latter part of the process being precipitated in a metallic state from the solution of chloride, by the action on the latter of the powdered charcoal employed in the charcoal filters. Carbon, therefore, being proved to have the power of precipitating gold from chloride solutions,‡ artificially produced, it is not unreasonable to suppose that if such solutions were formed naturally in the channels of veins, previous to the consolidation of the veinstone, they would be liable to have a portion of their gold precipitated where they came in contact with carbon, which might be present in the form of graphite either formed primarily from the alteration of vegetable matter; or secondarily, from the breaking up of carbonic acid into its constituents—carbon and oxygen—the oxygen being absorbed through the conversion of sulphides into sulphates, or through the oxidation of metallic solutions. The theory has already been advanced by Mr. W. H. Rands, Assistant Government Geologist of Queensland,§ that much of the gold in the Gympie reefs has probably been precipitated by the action of the carbon of the sedimentary rocks traversed by the reefs upon the original gold solutions, from which the reefs were formed.

The association, therefore, of microscopic globules of liquid carbonic acid gas with gold in the good gold quartz in some of the Californian mines may be an essential rather than an accidental attribute, and if so a study of this branch of inquiry, if applied to the gold-bearing veinstones of New South Wales, would probably lead to some practical results as affording a possible means of determining,

* Trans. R. Soc. Vict., 1868, VIII, p. 11; Siluria, by R. I. Murchinson, 1872 p. 465; Gold, by Lock, p. 759.
† Gold, by Lock, 1882, p. 777.
‡ Mr. Skey, however, contends that carbon acts less effectively than metallic sulphides as a precipitating agent on solutions of gold.—*Report Austr. Assoc. Adv. Sc. for* 1888 [1889], I, p. 155.
§ Gympie Gold Field Report, by W. H. Rands. *Queensland Parl. Papers*, 1889, C. A. 7, p. 4.

merely by a careful microscopic examination of surface specimens from a reef, whether that reef is likely or not to be gold-bearing at a depth, even when there is little indication of its being gold-bearing at the surface. The subject at all events has much to commend itself to the attention not only of the geologists on this Survey, but also to that of any who propose to study systematically the laws which govern the occurrence of gold in gold reefs. The observations, however, lately made by Mr. C. S. Wilkinson, at the Mount Morgan Mine, incline him to believe that in the solutions from which the gold at this mine was precipitated, gold was present as a sulphide rather than as a chloride, as might be inferred from the abundance there of basic sulphate of iron, the occurrence of which at Mount Morgan was first observed by Mr. Wilkinson. In the work which is now being prepared by the Geological Survey on the microscopic and other characters of the eruptive rocks of New South Wales, special attention will be given to the metalliferous veinstones, and the formations with which they are associated, more especially with reference to the probable form in which gold occurs (when present otherwise than as "free-milling" gold) in pyritous veinstones.

IV.—Association of Gold with other Metals.

The question as to the form in which gold occurs in the pyritous portions of gold-bearing veins is obviously one of vast importance to the interests of gold-mining in New South Wales, in view of the fact that hundreds of gold veins, which proved payable as far down as their oxidised portions extended, and the gold was consequently capable of being extracted by amalgamation, have had to be abandoned as soon as the sulphide ores were reached below the lowest limit of the zone of oxidation, which is commonly found to be co-incident with the water level. Below this point the yield of gold becomes diminished from two causes :—

(1) The specific gravity of the stone is frequently materially increased, so that the yield of gold per given weight of stone is lessened. For instance, if in the oxidised portion of the vein the stone weighs (say) two and a half tons per cubic yard, and yields one ounce of gold per ton, a cubic yard of the same veinstone, where highly charged with sulphide ore below the water level, if it weighs five tons instead of two-and-half, would yield only at the rate of one-half ounce of gold per ton. Such great differences, however, in the relative specific gravities of the oxidised, as compared with the unoxidised portions of veinstones, are rather exceptional, and the falling off of the yield of gold is therefore attributable, probably, rather to the second cause about to be described.

(2) The gold for the greater part in most sulphide ores ceases to be "free milling," and cannot, therefore, be extracted, excepting to a limited extent, by the ordinary processes of amalgamation. This resistance of gold, when in sulphide ores, to the amalgamating influence of the

mercury, has been attributed chiefly to two possible causes—(*a*) to the gold in the sulphides and arsenides being in an excessively fine mechanical state of division, so that the gold, though free (on this assumption), floats away in the water after it leaves the stamp-boxes without being attacked by the mercury; and (*b*) to the gold in the sulphides being present in some form other than as free gold, that is, chemically combined or alloyed with some other element.

This subject has been admirably treated in a paper on "The Association of Gold with other Metals in the West," by Richard Pearce.*

(*a*) MR. PEARCE'S EXPERIMENTS.—Mr. Pearce quotes some interesting experiments conducted by himself, which seem to show that in the case of the gold veins of Gilpin County, Colorado, the gold in the sulphide-bearing portions of the vein is combined in many cases with minute quantities of bismuth, in some cases with tellurium, and possibly in a few cases with arsenic. The discovery of sperrylite (arsenide of platinum) in Canada suggests to him the possibility of the occurrence of gold similarly combined, and he is of opinion that it is possible to produce arsenide of gold in minute quantities artificially, by passing the vapour of arsenic over thin sheet gold at red heat in an atmosphere of hydrogen, the surface of the gold during this experiment becoming covered with "a very fine greyish coating, * * which may have consisted of a compound of gold with arsenic." He does not, however, speak positively upon this point. The facts however, which he seems to have established with regard to the gold veins of Gilpin County, below the water level, are—

(1) That the gold is paler and baser here than in the upper oxidised portions of the veins.

(2) That tellurium and bismuth are frequently present, and sometimes arsenic, though little or no arsenical pyrites is observable.

And by practical experiment he has demonstrated that—

(1) Compounds of gold and bismuth, and of gold and tellurium, can be artifically formed, and that such artificial compounds are not attacked by mercury.

(2) Compounds cannot be formed of pure gold and iron pyrites by melting them up together, the gold remaining simply in a mechanical state of division in the pyrites, and not losing its standard.

(3) If bismuth be added to the gold and iron pyrites, and the three fused together, the matte so formed shows no trace of metallic gold, the gold having probably combined with the bismuth.

* The Association of Gold with other Metals in the West, by Richard Pearce, Argo, Colorado. *Trans. American Inst. Mining Engineers.* (Presidential address at the Washington Meeting, February, 1890.)

(4) If silver be added to the gold, iron pyrites, and bismuth, the gold does not combine with the bismuth, but forms a silver-gold alloy with the silver.

(5) If copper be added to the iron pyrites, bismuth, gold, and silver, the gold forms an alloy with the copper, but not with the bismuth and silver.

The last experiment, however, was tried only in the case of copper matte formed during the ordinary process of smelting, in which there was only a comparatively small percentage of silver and bismuth present.

Upon treating the matte with nitric acid Mr. Pearce observed that when the rest of the metals in the matte had passed into solution "very minute octahedra of this gold and copper alloy" were left behind.*

In New South Wales, as in America, gold has been found in association with bismuth and tellurium, as well as with copper pyrites and arsenical pyrites, iron pyrites, antimony, zinc, lead, &c.

(*b*) GOLD ASSOCIATED WITH BISMUTH AND TELLURIUM, AND IN SOME CASES COMBINED WITH THEM.—At Mount Shamrock, in Queensland, gold is largely associated with bismuth and tellurium. In the parish of Jingera, County Murray, near Captain's Flat, New South Wales, Mr. J. C. H. Mingaye, F.C.S., Assayer and Analyst to the Department,† discovered that tellurium was present in considerable quantity associated with the bismuth, and combined with it in the form of tetradymite.

At Kingsgate also, near Glen Innes, gold is found in association with the the bismuth, some samples of this metal assaying as much as 3 oz. of gold per ton.

In the case of the gold-bearing bismuth ores which have come under my notice, from Queensland in particular, I have been unable in most cases to see metallic gold in the native bismuth, though it is observable in abundance in the oxidised coating which invests the latter. This would seem to imply that the gold thus associated is usually alloyed with the bismuth.

Dr. J. Storer, however, has presented the Mining and Geological Museum of the Department of Mines, Sydney, with a specimen of native bismuth, showing free gold enclosed in the former metal, from the Eidsvold Gold-field of Queensland; and a similar enclosure of gold in metallic bismuth is reported to have been observed at the Kingsgate Mine, Glen Innes. No systematic search has so far been made for the possible presence in small quantities of bismuth and tellurium in the gold-bearing sulphide ores of N. S. Wales, the occurrence of these two metals

* Analyses made by Professor Liversidge and Dr. Leibus of the alluvial golds from various parts of New South Wales show that the quantity of copper present is inappreciably small as compared with that of the silver, which seems to show that silver has a greater affinity for gold than copper has, the silver varying from 1 to 33 per cent. and the copper from traces to ·27 per cent.

† Report Austr. Assoc. Adv. Sci. for 1888 [1889], I, p. 116; Records Geol. Survey N. S. Wales, 1889, I, pt. 1, p. 26.

having been recorded chiefly when they were present in some considerable quantity. Bismuth has been proved by analyses made by Mr. W. A. Dixon, F.I.C., F.C.S., to be present in most cases in the copper ores of the Great Cobar Copper Mine. Samples analysed by him in 1878 yielded from ·21 to 2·66 per cent. of metallic bismuth, and the refined copper from the ore containing ·419 per cent. of bismuth. Although this copper contained 8 oz. of silver per ton, Mr. Dixon's analyses show that traces only of gold were present, a fact which proves that bismuth ores in New South Wales are not always gold-bearing. The discoveries of Sandberger that bismuth is occasionally present in hornblende from the more recent eruptive rocks, and also generally in lithia-mica, shows the probability of its being a somewhat widely distributed metal, and both it and tellurium may yet be found to be present in minute quantities in the gold ores of New South Wales in many more instances than are at present known; and in such cases, the gold will no doubt be alloyed with the bismuth and tellurium, obviously a very important factor to be determined in connection with the subsequent treatment of such ores.

(*c*) GOLD ASSOCIATED WITH ARSENICAL PYRITES AND ARSENIC, AND POSSIBLY COMBINED WITH ARSENIC.—The existence of arsenide of platinum, and the practical experiments of Mr. Pearce upon the artificial production of an arsenide of gold, considered in conjunction with the well-known fact that gold exudes in the form of "moss gold" from arsenical pyrites, when the latter mineral is heated at a temperature below the ordinary fusion point of gold, render the occurrence in nature of such a compound not only possible, but probable.

Gold occurs in association with arsenical pyrites in a great number of gold veins in New South Wales, as for instance at the New Reform Mine, Lucknow, where it is also associated with native arsenic; at Sunny Corner; at the Prince William Mine, Ironbarks, near Orange; the Star of Peace Mine, Hill End; Mandurama, &c. According to assays by Professor Liversidge, F.R.S.,* a sample of arsenical pyrites from the Prince William Mine, Ironbarks, near Orange, yielded by assay—

	oz.	dwt.	gr.	
Gold	213	19	8	per ton.
Free Gold	4	11	3	„
Silver	0	9	3	„

The small quantity of silver as compared with the gold in this case proves that the gold was not to any appreciable extent combined or alloyed with the silver, and unless it was in some state other than that of free gold, it is difficult to understand why only about two per cent. of the whole gold present was capable of being extracted by amalgamation. This fact is somewhat in favour of part of the gold

* Ann. Report Dep. of Mines N. S. Wales for 1875 [1876], p. 161.

being present as arsenide, and if the latter be true it will have a very important bearing upon the probable volatility of any gold so combined, as will be explained in the sequel.

(*d.*) GOLD ASSOCIATED WITH COPPER PYRITES, AND PERHAPS COMBINED WITH COPPER.—The presence of gold in copper ores in New South Wales has been proved by several analyses and assays made by this department. In the Annual Report of the Department of Mines for 1875,* Professor A. Liversidge gives returns as follows of three samples of copper ore assayed by him from Mitchell's Creek:—

Sample 31, containing visible gold. Gold, 1 oz. 2 dwt. 20 gr. per ton; percentage of metallic copper, 9·48.

Sample 32, containing visible gold. Gold equal to 4 oz. 10 dwt. 8 gr. per ton; percentage of metallic copper, 9·48.

Sample 33, red oxide and green carbonate of copper. Contained gold equal to 14 oz. 10 dwts. 6 grs. per ton; per centage of metallic copper, 25·79.

In the last case there is no mention of any visible gold.

Again, in the Annual Report for 1882,† an analysis by Mr. J. C. Watt, of copper ore from the Monaro District, shows gold to be present at the rate of 2 oz. 19½ dwts. per ton; silver at the rate of 18 oz. 15½ dwts. per ton; the percentage of metallic copper being 27·4 per cent. In this case the gold may have been alloyed with the silver instead of being combined with the copper.

The discovery, by Mr. Pearce, that in the case of copper mattes containing bismuth and silver, gold is combined with the copper, and not with the silver nor with the bismuth, suggests the possibility that in cases where several pyritous gold-bearing ores are present, such as those of arsenical pyrites, iron pyrites, magnetic pyrites, and copper pyrites, the bulk of the gold may be contained in the copper pyrites. If this is the case, the richness in gold of many "slimes" may easily be explained by the well-known tendency of copper pyrites, on account of its brittle nature, to pass into slime during pulverisation. At Sunny Corner, for instance, and at Mandurama, at the Junction Mines, all the pyritous ores above mentioned are present; but it is not yet known, I believe, which of them carries most gold. and this question, with regard to the latter mine in particular, is one of vital importance as relating to the question of the most suitable machinery for the concentration of its sulphide ores.

With regard to the gold-bearing pyritous ores of New South Wales it would appear to me that, if the gold in the ore be alloyed at all, it is as probable that it is alloyed with minute quantities of copper, as that it is alloyed with bismuth and

* p. 144. † p. 16.

tellurium. If, however, some of the golds of New South Wales have ever been alloyed with copper when present in sulphide ores, it must have been the case that during the natural process of oxidation in the upper parts of the veins, the copper has been parted from the gold by oxidation, as no samples of natural gold contain copper to any great extent, so far as at present known. It has been stated that some of the Bingera gold contains a certain amount of copper, but my Colleague, Mr. G. A. Stonier, Geological Surveyor, who has recently consulted Mr. Heywood, of the Mint, on this subject, informs me that the foreign metal associated with the Bingera gold is iridium, and not copper.

The following analyses made at the Royal Mint, Sydney, show that the Bingera gold, which is popularly supposed to contain a good deal of copper, is almost wholly composed of gold and silver:—

Bingera gold.	Gold.	Silver.		Total.
A17,892	·9090	·085	=	·994
921	·9230	·070	=	·993
18,006	·9135	·080	=	·9935
226	·9140	·075	=	·989
390	·9145	·080	=	·9945
461	·9210	·070	=	·9910

In the case of the copper pyrites at the Junction Mine, near Mandurama, Mr. Hogue, the manager, states that his experiments show that the gold at this mine is present chiefly in the magnetic pyrites, rather than in the arsenical and iron pyrites, and copper pyrites.

The results of the samples selected from this mine, and assayed by Mr. J. C. H. Mingaye, show that traces only of gold are to be detected in the magnetic and in the iron pyrites, each of these minerals having been isolated and assayed separately. The arsenical pyrites and copper pyrites have yet to be isolated and assayed, and the result of these last assays may throw important light on this question.

(*e*) Gold Associated with Stibnite and Metallic Antimony.—Gold occurs associated with metallic antimony at the New Reform Mine, Lucknow, and with stibnite at several gold-bearing reefs in the Hillgrove District, including the Eleanora Reef, and Baker's Creek, in the Macleay District, and at the Lunatic Gold-field. At the New Reform Mine, the relation of the gold to the metallic antimony is well shown in a piece of ore from here, which Mr. C. S. Wilkinson has had cut and polished, and which shows the gold to be present unalloyed in the form of small particles of irregular shape from $\frac{1}{40}$ to $\frac{1}{30}$ of an inch in diameter imbedded in the native antimony, and also as interstitial films in cracks in the latter.

In the sulphide of antimony of the Hillgrove District, Mr. G. A. Stonier informs me that the gold appears to be present in three forms:

(1) As native gold, very fine.

(2) As pale native gold, the gold being evidently alloyed with some other metal.

(3) As gold rust.

A specimen of the sulphide of antimony lately presented to the Mining and Geological Museum by Mr. Moses, of Armidale, shows gold to be present in patches or minute vughs in the stibnite in the form of a very finely divided ochreous powder. Minute quantities of quartz are in most cases associated with it, though in places the gold powder is slightly isolated from the quartz, and is thoroughly intermixed with the delicate prisms of the stibnite round the edges of the small cavities. This gold rust presents the appearance of a dull ochreous brown powder, but can readily be burnished, so as to show a bright metallic lustre.

A sample of pure stibnite selected by Mr. C. S. Wilkinson, from the Eleanora Reef in 1883, and assayed by the Department's Assayer, yielded—

Fine gold at the rate of 2 ozs., 12 dwts. per ton.
,, silver ,, ,, 19½ dwts. ,,

A sample of stibnite from the Macleay District assayed at the Department of Mines, gave—

Gold—3 dwts. 6 grs. per ton.
Silver—traces.

Other associations of gold in gold-bearing ores in New South Wales, and the loss of gold which results from the roasting of sulphide ores, in which gold is associated, alloyed, or combined with some volatile element, will be discussed in a subsequent paper by the Author in the next part of this publication.

[*To be continued.*]

XVII.—Analyses of Samples of Cokes, manufactured from various Coke-producing Coals in the Northern, Southern, and Western Coal Districts of N. S. Wales: by J. C. H. MINGAYE, F.C.S., Analyst and Assayer.

I.—Introduction.

THE bulk of the enormous amount of coke consumed in smelting operations in the Broken Hill District, about one thousand three hundred and ten tons, per week, is imported from England.

The following figures are supplied by Mr. William Knox, the Secretary of the Broken Hill Proprietary Company's Mine, as to the quantity consumed per week for smelting operations:—

	Present requirements.	Estimated future requirements.
Broken Hill Proprietary Company	550 tons.	800 tons.
British Broken Hill Proprietary Company.........	350 „	450 „
Broken Hill Proprietary Block 14 Company	170 „	170 „
Broken Hill Junction Silver-mining Company ...	80 „	160 „
Australian Smelting and Refining Company	160 „	160 „
	1,310 tons.	1,740 tons.

The Broken Hill Proprietary Company also furnish the following figures as to the cost of the various descriptions of coke delivered at Port Pirie:—

	Average cost per ton.		
English coke, 18,144 tons	£3	7	8
German coke, 2,750 tons	2	19	6
New Zealand coke, 2,000 tons	2	17	6
New South Wales coke, 4,880 tons..	2	13	6
British Broken Hill Proprietary Company—English coke, 10,581 tons ...	3	4	4

Information regarding analyses of the coals from the different Coal-fields of New South Wales, will be found in the *Mineral Products of New South Wales*, published by the Department of Mines, also in the *Minerals of New South Wales*, by Professor Liversidge, M.A., F.R.S.

Ash.

Prof. Liversidge states in *The Minerals of New South Wales, &c.*, as follows:— "The northern coals yield from 2·7 per cent. to 11·51 per cent. of ash, with an average of 6·80 per cent.; the Western district coals range from 6·24 to 12·91

per cent., and average 9·78 per cent. The Southern district coals, omitting the samples which seem to be somewhat exceptional in character, yield from 4·41 per cent. to 18·52 per cent., and average 10·01 per cent. of ash.

Sulphur.

	Number of specimens.	Average percentage of sulphur.
Northern coal-fields..	42	·88
Western ,, ...	25	·73
Southern ,, ...	27	·76

I found it almost impossible to strike an average of the amounts of ash in the coals, analyses of which were made in the Laboratory, as in most cases the samples were taken by prospectors from exposed outcrops, and, therefore, did not represent a true average; and in few cases were samples received from working collieries. On comparing the average percentage of ash with that of the English coals it will be noticed that it is much higher, although the New South Wales Northern coal compares favourably with the German, American, and French coal. As regards the presence of sulphur, the coals of New South Wales are exceptionally free from that element, and I think will, without doubt, compare in this respect with coal in any part of the world.

By direction of the Hon. the Minister for Mines and Agriculture, I conducted the following investigations regarding cokes made from the coals of the Southern, Western, and Northern Districts of New South Wales, with a view of ascertaining their suitability for metallurgical purposes.

II.—Cokes of the Northern District.

Locality.	Specific gravity.	Moisture at 100° C.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
1. Rix's Creek, Singleton........................	1·328	·63	·36	87·81	10·67	·54
2. Coke used in Laboratory for fuel	1·313	1·24	3·31	85·68	12·35	·42
3. Coke made from unwashed coal, Thornley Colliery, East Maitland	1·267	·10	·30	88·70	9·83	1·07
4. Co-operative Colliery, Wallsend	1·308	·41	·21	87·36	11·50	·52
5. Purified Coal & Coke Co., Newcastle ..	1·339	·31	·46	90·88	7·93	·42
Average	1·311	·538	·328	88·086	10·456	·594

No. 1 (966).—This coke was "hard burnt," received in pieces measuring about one foot eight inches long. Blackish-grey in colour, dense, and hard. It should be

readily handled without breaking or crumbling, and bear a heavy burden. Throughout the coke were visible pieces of a hard shaly material, some of which had burnt white. In parts the coke was coated with thin layers of ferrosoferric sulphide. Ash: yellowish tinge, flocculent.

No. 2.—Average sample of the coke supplied to the Laboratory for fuel.—Blackish-grey in colour; in length, measuring more than a foot. In most pieces large fissures were visible, running along the entire length of the pieces. Coated in thin layers with ferrosoferric sulphide, which exhibited the characteristic play of colours, dense, and fairly hard. This coke was not "hard burnt," and although it should bear handling without crumbling, is not so good a sample as the former one for smelting purposes. Ash: reddish tinge, with white specks, flocculent, and fairly free from heavy grit. A trace of lead and copper was detected. An examination of a large quantity of the ash was made for gold and silver, with the result that neither of these metals were detected.

No. 3 (1548).—Made from unwashed coal, Thornley Colliery, East Maitland.—Coke, firm and bright, with a silvery metallic lustre, in pieces measuring over one foot in length. This is a good description of coke, and should readily stand handling without breaking or crumbling, and bear the weight of a heavy burden; "hard burnt." Ash: buff-coloured, flocculent; contains a large proportion of a hard siliceous substance, the bulk of which could have most probably been removed by washing the coal before coking. A test for copper, lead, gold, and silver, gave negative results.

No. 4 (1885).—Co-operative Colliery, Wallsend.—Blackish-grey, inclined to silvery, dense, and hard. In pieces measuring over one foot six inches in length; "hard burnt." Hair-like threads were observed in this coke, occurring in patches somewhat resembling fibre. This coke should readily stand handling without breaking or crumbling, and bear the weight of a heavy burden. Ash: yellowish in colour, flocculent. The ashes containing a fair proportion of a hard gritty substance. A test for copper and lead gave negative results.

No. 5 (2057).—Purified Coal and Coke Company, Newcastle.—Coke, silvery and metallic in appearance, dense and compact. In pieces measuring over one foot in length; "hard burnt." This sample can be readily handled without breaking or crumbling, and should bear the weight of a heavy burden of flux and ore. An excellent coke for metallurgical operations. Ash: yellowish in colour, flocculent; contains many pieces of a hard gritty substance. An examination of a large quantity of the ash was made for the presence of gold and silver, with the result that neither of these metals were detected.

III.—Cokes of the Western District.

Locality.	Specific gravity.	Moisture at 100° C.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Cullen Bullen Coal Co. Second experiment, washed before coking..........	1·716	5·30	1·92	74·06	18·20	·52

Only one sample was received from the Western District.

No. 1 (1479).—Coke, dull in colour, honeycombed, and not extra firm, pieces not in very large lengths. A very poor quality of coke, the ashes containing a very large amount of silica. The moisture in this sample is exceptionally high; this may probably be due to water having been used to cool the coke after coking Through the coke large pieces of a hard siliceous substance were visible, showing that the washing operations had not been a success. Ash: almost white in colour, granular, dense. About one-third of the ash consists of hard siliceous grit. A minute trace of copper was detected.

IV.—Cokes of the Southern District.

Locality.	Specific gravity.	Moisture at 100° C.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Bulli Coke Works. Stated to have been made from washed coal	1·469	1·53	·79	83·77	13·45	·46
Wollongong Coke Works............	1·566	·26	·29	87·75	11·27	·43
Undanderra ,, ...	1·471	1·35	·73	83·92	13·41	·59
Coke from Moss Vale	1·400	....	1·35	79·20	19·00	·45
Coke from Wollongong........	1·503	·52	....	84·60	14·36	·53
,, ,, ...	1·454	·53	....	86·05	12·83	·59
Average	1·477	·698	·525	84·21	14·05	·508

No. 1 (892).—Bulli Coke Works, stated to have been made from washed coal.—Coke, fairly bright, blackish-grey in colour, very dense and hard; should stand readily handling without breaking, and will bear the weight of a heavy burden. On examining the sample, pieces of a hard shaly substance were visible through the coke. Ash: light-grey in colour, dense. A strong trace of lead and copper was detected. An examination of a large quantity of the ash for gold and silver failed to detect either of these metals.

No. 2 (893).—Wollongong Coke Works. Coke prepared from unwashed coal.—The same remarks apply to this coke as to the physical appearance of No. 1. The sample contains less ash than the former one. Ash: buff-coloured, dense. A minute trace of lead and copper was detected.

No. 3 (894).—Undanderra Coke Works.—Coke blackish-grey in colour, dense, and very compact. Throughout the coke, many pieces of hard, shaly matter were visible. From its hardness, this coke can be readily handled without breaking, and should stand the weight of a heavy burden of ore and flux. Ash: light-grey in colour, contains a large proportion of a heavy grit. A trace of copper detected. An examination of a large quantity of ash for the presence of gold and silver gave negative results.

No. 4 (905).—Coke from Moss Vale, made from unwashed coal.—Coke, fairly well swollen-up, fine and lustrous. Ash: white in colour, granular. The coal from which this coke was made yielded, on analysis, as follows:—

	Proximate analysis.	
Hygroscopic moisture	2·28	
Volatile hydrocarbons	33·07	
Fixed carbon	52·22	Coke, 64·65 %
Ash	12·43	
	100·00	

Specific gravity, 1·362.
Sulphur in coal, ·590 %

No. 5.—Mount Kembla, Wollongong.—Bright and firm, blackish-grey in colour. It can be handled without readily breaking, and should stand the weight of a heavy burden of ore and flux. Ash: light-grey in colour, contains a large proportion of grit, dense. A trace of copper detected.

No. 6.—Coke from Wollongong.—The same remarks apply to this sample.

V.—*Summary of Analyses of New South Wales Coke.*

Locality.	Fixed Carbon.	Ash.	Sulphur.
New South Wales—			
Northern District	88·09	10·45	·594
Southern District	84·21	14·05	·508
English	91·56	6·55	1·260
American	90·13	8·68	·685

The following analyses are furnished, showing the composition of the ashes of the cokes:—

NORTHERN DISTRICT.

No.	Locality.	Ash, per cent.	Silica.	Alumina.	Sesquioxide of iron.	Manganese (Mn. O.)	Lime.	Magnesia.	Potash.	Soda.	Phosphoric Acid.	Sulphuric Acid.	Total.
1	Rix's Creek, Singleton	10·67	56·07	31·57	7·47	..	2·38	trace.	·72	·96	·22	·23	99·62
2	Coke used in Laboratory for fuel.	12.35	56·26	28·33	11·52	·27	1·00	·16	1·27	·04	·67	·82	100·34
3	Made from unwashed coal Thornley Colliery, East Maitland.	9·83	57·66	30·33	9·06	strong trace.	·65	·23	1·50	trace.	·64	·19	100·25
4	Co-operative Coal Company.	11·50	59·64	34·56	2·62	trace.	·75	1·13	1·26	·04	·30	·12	100·42
5	Purified Coal and Coke Company.	7·93	51·20	34·33	9·14	do	2·63	·55	·19	·54	1·80	Nil.	100·38
	Average	10·456	56·16	31·82	7·962	·054	1·482	·414	·988	·316	·726	·272	..

WESTERN DISTRICT.

No.	Locality.	Ash, per cent.	Silica.	Alumina.	Oxide of iron.	Manganese (Mn. O.)	Lime.	Magnesia.	Potash.	Soda.	P_2O_5	SO_3	Total.
1	Cullen Bullen Coal Company	18·20	80·20	17·25	trace.	trace.	1·68	·18	1·10	trace.	trace.	trace.	100·41

SOUTHERN DISTRICT.

No.	Locality.	Ash, per cent.	Silica.	Alumina.	Sesquioxide of iron.	Manganese.	Lime.	Magnesia.	Potash.	Soda.	Phosphoric Acid.	Sulphuric Acid.	Total.
1	Bulli Coke Works..........	13·45	53·84	36·79	2·53	strong trace.	2·29	1·62	1·44	·02	·30	·68	99·51
2	Wollongong Coke Works ..	11·27	55·24	39·67	1·75	do	1·28	trace.	·97	·38	·67	·29	100·25
3	Unanderra do ..	13·41	55·49	39·60	1·11	do	1·72	·15	1·09	·46	·51	·24	100·37
4	Coke from Moss Vale	19·00	69·75	23·83	3·17	trace.	1·00	·45	·33	·45	trace.	·31	99·29
	Average	14·282	58·58	34·97	2·14	..	1·572	·555	·957	·327	·370	·380	..

VI.—*Phosphoric Acid.*

The ashes of the coals of New South Wales yield much less phosphoric acid than the English, which is greatly in their favour when the coals or cokes are required to be used for iron-smelting purposes.

	No. of Samples.	Maximum.	Minimum.	Mean.
New South Wales—				
Northern District..............................	5	1·800	·22	·726
Southern District............................	4	·670	trace.	·370
*Western District...........................	8	·640	trace.	·290
Great Britain	6	6·633	·74	1·843

VII.—*General Remarks.*

For further information regarding the composition of the ashes of New South Wales coals, I would refer to the various analyses made by Professor Liversidge and Mr. W. A. Dixon, F.C.S.†

A coke required for metallurgical purposes should exhibit the following physical appearances:—Blackish-grey in colour, with a more or less fatty lustre, in that prepared from coals rich in oxygen, to a light iron-grey, with a fine silky or almost metallic lustre, the coke yielded by coking coal often resembling in structure a mass of melted slag or lava. A good description of coke should be uniform throughout, without any great admixture of fibre or shaly matter, also dense and

* Minerals of New South Wales, &c., by Professor Liversidge.
† Minerals of New South Wales, &c., pp. 140–141.

compact. The coke should be "hard burnt" so as to exhibit the latter quality, and therefore be capable of resisting the action of the blast. Coke of this quality carries twice the burden of flux and ore.

The objection to the uses of the New South Wales cokes at Broken Hill seems to be the excessive amount of ash present in the samples over the cokes manufactured from the British coals and elsewhere, the ash being useless material, besides hindering the combustion of the coke. As an example, a coke yielding ten per cent. of ash would represent ten tons of useless material in every one hundred tons of coke, which freight would have to be paid for.

The ash in the northern cokes averages in five samples 10·45 per cent., one of the samples yielding only 7·93 per cent., which is little more than one and three-quarters per cent. higher than the average given of seventeen samples of English coke. I refer to that manufactured by the Purified Coal and Coke Co., Newcastle, which, as regards its physical appearance and make, is an excellent description of coke. Nos. 1, 3, and 4 are good descriptions of coke, they being well made in long lengths, "hard burnt," and capable of standing the pressure of a heavy burden of ore and flux.

Professor Liversidge gives the mean of forty-two analyses of the ash in the coals of the Northern District as 6·80 per cent., thirteen of the samples yielding under five per cent. of ash. I venture to think that the amount of ash present in the northern coals could be greatly reduced, at a comparatively low cost, by a thorough system of grinding, screening, and washing the "slacks" before coking; especially in those coals yielding four, five, and six per cent. of ash.

The western coals, as a rule, do not yield a good description of coke. The coals often only coking when freshly obtained from the pit. The amount of ash present is usually high compared with the ashes of the Northern District, though lower than the Southern. The samples received from the Southern District all yielded high results for ash, and in one or two cases, the samples furnished were stated to have been washed before coking; if this is the case, it is very evident that the washing machines, if properly worked, are not suitable for this class of coal. In most of the samples many pieces of hard shaly matter were visible, and the ashes contained a large amount of a heavy gritty substance. The cokes were well burnt, very dense and compact, and would be a good description of coke for metallurgical purposes if containing less ash.

The whole question as to the uses of our cokes for metallurgical purposes at Broken Hill and elsewhere, hinges on the amount of ash present, and suggests a systematic and thorough method of sorting, screening, and washing the coals before coking, so as to obtain an article as free from ash as possible. From experiments

made in the Laboratory, on the small scale, it was found possible to greatly reduce the amount of shaly matter in the coal by screening and washing. As information should prove useful as to the cost of washing and coking, also the description of washing-machines and ovens in use in Great Britain and the Continent, I venture to furnish the following, obtained from some of the best authorities on the subject. In France the cost is given as follows:—

	d.
Labour	5·1
Other Charges	1·2
Loss	8·3
Total	14·6

Or about 1s. 2d. per ton of washed coal, while on a produce of sixty-six per cent. of coke would cost 1s. 10d. per ton of coke.

Michworth's purifier.—These machines are used in Scotland, Cumberland, Derbyshire, Wales, to purify from twenty to one hundred tons of coal per day, at a cost not exceeding threepence per ton, and with a loss not exceeding 2·0 per cent. of coal.

The Bochum Mining and Smelting Co., in Westphalia, in order to obtain a pure coke for their blast furnaces, established at their collieries a complete set of apparatus for working the coal on the Lührig system. It is stated by them that one thousand tons of coal can be washed in this machine. Before washing, the coal contained eight per cent. of ash; after washing, 3·6 per cent of ash. The cost of washing is given at less than one half-penny per ton of coal. The cost of handling being less in Great Britain and the Continent, of course, a liberal allowance will have to be added for treatment of the New South Wales coals. Many other descriptions of washing-machines are used, those on the hopper-dredge system being largely in use, and are stated to perform excellent work.

The Coal is usually coked in ovens of the bee-hive pattern, there being a very great variety of ovens in use, each of which claim their respective qualities.

In America, cokes containing seven, nine, ten, and eleven per cent. of ash are used for smelting purposes; the coke made at the Broadford Works contains from nine per cent. to nearly twelve per cent. of ash. At Rockwood, Roane Co., Tennessee, a coal is coked for use in the blast furnaces containing 5·27 per cent. to 11·52 per cent. of ash. A coke made in Colorado, and used principally by the lead smelters in cupolas, &c., contains from 6·6 per cent. to 7·15 per cent. of ash.

In conclusion, I may point out that the coals of New South Wales, though higher in ash than the average of British coals, would be greatly improved in quality as regards the ash present, by a thorough systematic method of washing before coking, especially the northern coals, which form excellent coke.

XVIII.—Note on Mr. J. C. H. Mingaye's Analyses of N. S. Wales Coals and Cokes: by T. W, Edgeworth David, B.A., Geological Surveyor.

I would venture to summarise the conclusions drawn by Mr. Mingaye in this interesting and valuable Report on the composition of the coke manufactured in New South Wales, and that of their ashes, and to supplement these with a few remarks.

The results of these analyses show fairly well probably the relative values of the cokes of the different districts represented by the samples sent. While, however, the Newcastle Series of the Northern Coal-field and the Southern Coal-field were tolerably well represented, only one sample was received from the Western Coal-field (and this too was very imperfectly purified), none were received from the Tomago, nor from the Greta Series of the Northern Coal-field, and none from the Gunnedah Coal-field. The results of these analyses are not, therefore, indicative of the values of all the cokes that are, or can be produced in New South Wales, though they may be taken to be representative of the most important coke-producing mines.

The coals of New South Wales belong, so far as at present known, to five distinct formations, which occur in the following order, the oldest and lowest in the series being placed first:—

(1.) Rhacopteris Beds, developed principally in the Stroud District.—Contain a few seams of dirty, unworkable coal, from a few inches up to four feet thick.

(2.) Greta Coal-Measures.—Contain valuable coal-seams, which, however, do not form a good coke.

(3.) Tomago Coal-Measures.—Contain productive coal-seams, some of which form a fair coke, and, in the case of the Rix's Creek measures (if they are to be referred to this series), a very good coke.

(4.) The Newcastle, Bulli, and Rix's Creek (?) Coal Measures.—Contain valuable productive coal-seams, which form a very good coke, except in the case of some of the seams of the Western Coal-field, which either do not coke, or lose their coking properties upon exposure.

(5.) Clarence Coal Measures.—Contain productive seams, from which a fair coke is manufactured, at Ipswich and Burrum, in Queensland, but hitherto no workable seams have been discovered in these measures in New South Wales.

Mr. Mingaye's Report shows that the cokes manufactured from the Newcastle and Rix's Creek seams are probably superior for smelting purposes to the cokes of the Southern and Western Coal-fields, at any rate so far as percentage of ash is concerned.

The coke made by the Purified Coal and Coke Company, Newcastle, heads the the list in this respect, containing only 7·93 per cent. of ash, a return of which compares favourably with the average amount of ash present in the cokes of Europe and America. Rix's Creek coke is not far behind, with 10·67 of ash.

The cokes made from the Bulli Seam, in the Southern Coal-field, are a trifle higher in ash than those of Newcastle and Rix's Creek; but it would perhaps be invidious to assume that they are therefore of less value for smelting purposes, taken as a whole, than the Newcastle and Rix's Creek cokes; for no doubt the exact state of the fixed carbon in a coal has much to do with the value of the coke produced from it, the fixed carbons in different cokes not necessarily having cent for cent a uniform value.

It is worthy of note that in one case here the coke made from the unwashed coal was proved to contain more ash than that made from coal stated to have been purified by washing. As however Mr. Mingaye points out, the washing in this case had been very imperfectly carried out, as evidenced by the presence of fragments of clay shale in the coke.

The sample of coke forwarded from the Western District exhibited similar evidence of having been imperfectly purified.

As regards their ashes, those of the New South Wales cokes are more siliceous, and, consequently, more refractory than those of the cokes of Europe and America, and contain less lime and iron; but on the other hand, are freer from phosphorus and sulphur than either of the preceding.

Mr. Mingaye's general conclusion is that, with increased care in the manufacture, especially with regard to the washing appliances used in purifying the coal for making coke, cokes can be produced in New South Wales equal in every respect, probably, to those imported from Europe and America, except with regard to the more refractory nature of the ash in the first-named, a defect, however, which is partly compensated for by their greater freedom from such deleterious elements as sulphur and phosphorus. It is to be hoped that this systematic research into the suitability for smelting purposes of the cokes of New South Wales, instituted by the Honorable the Minister for Mines and Agriculture, will be the means, not only of calling attention to the value of the article now produced, but will also lead to improvements being made in its manufacture by calling attention to the present defects.

XIX.—*Lepidodendron australe*, M'Coy—Its Synonyms and Range in Eastern Australia: by R. ETHERIDGE, JUN., Palæontologist and Librarian.

I.—Introduction.

WE are indebted to Mr. William Carruthers, F.R.S., &c., for the first description of an Australian *Lepidodendron*, in his paper, "Notes on Fossil Plants from Queensland, Australia*," wherein is described the plant referred by the author to *Lepidodendron nothum*, Unger, a species characteristic of the Upper Devonian beds of Thuringia. For the second description of a species of this genus we are similarly indebted to Sir F. M'Coy, F.R.S., &c., who in 1874 furnished a full diagnosis† of his long before named‡ *L. australe*, from the Lower Carboniferous rocks of the Avon River, Gippsland, Victoria. Mr. Carruthers assigns the supposed *L. nothum* from Queensland to the "Old Red Sandstone," the localities given by the late Mr. R. Daintree being Mount Wyatt, Canoona, and the Broken River.§ Prof. O. Feistmantel,‖ who has twice described both species, accepts M'Coy's determination of the Gippsland *Lepidodendron* and its horizon, and follows Carruthers in his views of the identity and age of the form found in Queensland. He further records the occurrence of the latter in New South Wales.

The reference of an Australian *Lepidodendron*, however, to the age of the Devonian has not passed unchallenged, for Prof. M'Coy questions¶ the identity of the supposed *L. nothum* from Queensland, as described by Carruthers, with the European species of the same name; and Mr. Robert Kidston, an acknowledged authority on the genus *Lepidodendron*, distinctly disagrees with such a view, both as expressed by Carruthers and Feistmantel. Prof. M'Coy considers the Queensland plant as probably identical with the Victorian, whilst Mr. Kidston** places the former as a synonym of the latter. It is contended by the Writer that the two are one and the same plant, and should be known as *Lepidodendron australe*, M'Coy.

II.—Previous Knowledge of Lepidodendron *in Australia.*

It is but fair to a number of the earlier Australian Geologists to point out that the occurrence of *Lepidodendron* was known some time before Sir F. M'Coy's Avon River species came to light, in what was then, geographically

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* Quart. Journ. Geol. Soc., 1872, XXVIII, p. 353.
† Prod. Pal. Vict., 1874, Dec. I, p. 37, t. 9.
‡ Victorian Exhibition Essays, 1861, p. 163.
§ Quart. Journ. Geol. Soc., 1872, XXVIII, p. 289.
‖ Since this was written we have received the sad news of Prof. O. Feistmantel's death.
¶ Prod. Pal Vict., 1874, Dec. I, p. 38.
** Cat. Pal. Plants Brit. Mus., 1886, p. 231.

speaking, N. S. Wales, notwithstanding that the statements of the various authors in question appear to have been looked upon as "reports that have at times been circulated as to the occurrence of a *Lepidodendron* in the Australian coal-beds."* The expression "coal-beds" must be taken in a wide or family sense, as including the whole series of Carboniferous beds, not merely the Coal-Measures.

As early as 1848, the late Rev. W. B. Clarke, F.R.S., &c., recorded† *Lepidodendron* from the shales of the Manilla River, and on the Namoi and Gwydir Rivers, from the grits and sandstones of the Paterson River, and from the hard siliceous metamorphic rocks of Colocolo, on the Allyn River, associated with Brachiopoda and trilobites. The first figure of an Australian *Lepidodendron*, is, I think, that given in one of the much-overlooked Reports of the late Samuel Stutchbury, the first Government Geologist of New South Wales. In his "Tenth Tri-monthly Report on the Geological and Mineralogical Structure of New South Wales," dated Berrigal, July 1st, 1853,‡ containing a description of the Liverpool Plains, and Valley of the Horton River, a cast of a *Lepidodendron* is given. It was discovered in "argillaceous shales and sandstones," presumedly, from the context, at the crossing place over the Oaky Creek, four miles from Cobedah. Although the figure is merely in outline, the species is unmistakably *L. australe*, M'Coy, in all its characters. Stutchbury remarks, "Having found several specimens of *Lepidodendron* in the argillaceous shales and sandstones, and believing that they have not hitherto been figured as occurring in the Australian coal measures, I take this opportunity of doing so, for the purpose of calling attention to these important extinct vegetable remains." In 1855 Mr. F. Odernheimer's survey of the Peel River District revealed the presence of *Lepidodendron* in soft slate, associated with metamorphosed rocks of that neighbourhood.§ The next year (1856) Mr. J. S. Wilson announced the discovery of this plant at Goonoo Creek, near Tamworth, but he did not give any definite information regarding its horizon there‖. A full list of localities where *Lepidodendron* had been found up to 1861, was given in that year by the Rev. Mr. Clarke,¶ inclusive of Goonoo, and a further discovery at Canoona, on the Fitzroy River, in Queensland.

In another paper Clarke summarised** these various discoveries, and further remarked, "In 1849 I requested the late Admiral P. P. King to take with him to England some additional New South Wales fossils. Among them was a supposed Lepidodendron, found by my late friend Leichhardt, about seventy-five miles from the coal-beds of Mount Wingen. . . . . . . Since that time

* W. Carruthers, Quart. Journ. Geol. Soc., 1872, XXVIII, p. 350.

† On the Genera and Distribution of Plants in the Carboniferous System of New South Wales.—*Quart. Journ. Geol. Soc.*, 1848, IV., p. 60.

‡ N. S. Wales Legislative Council Papers, 1853, 235 A, p. 9 (f'cap, Sydney, 1853).

§ On the Geology of Part of the Peel River District, in Australia.—*Quart. Journ. Geol. Soc.*, 1855, XI., p 399.

‖ Notes on the Geology of the Neighbourhood of Sydney, Newcastle, and Brisbane.—*Quart. Journ. Geol. Soc.*, 1856, XII, p. 283.

¶ On the Relative Position of certain Plants in the Coal-bearing beds of Australia.—*Quart Journ. Geol. Soc.*, 1861, XVII, p. 354.

** On the Age of the New South Wales Coal-field. *Ann. Mag. Nat. Hist.*, 1862, X, p. 81.

Mr. Stutchbury and myself collected such *Lepidodendra* abundantly, as may be seen by reference to our Geological Reports." Mr. Clarke subsequently stated* that the plant conveyed to England by Admiral King was, he was informed by Prof. M'Coy, *Lepidodendron tetragonum* of the English Coal-fields, an opinion supported by that eminent botanist, the late Sir Charles Bunbury.

These quotations and references will show, tolerably well, the conditions under which *Lepidodendron* was known to the pioneers of Geology in Eastern Australia previous to the discovery of M'Coy's *L. australe*; and the original remarks of the authors quoted, one would have thought, would have been sufficiently clear to render unnecessary any clearing up of reports "that have at times been circulated as to the occurrence of a *Lepidodendron* in the Australian coal-beds."†

III.—Lepidodendron australe *and* L. nothum.

The essential points of M'Coy's description of the former species are the rhombic leaf-scars with straight thick boundaries, the vascular scars small, and oval or rounded, placed either in the middle, or towards the upper angle of the scars, and in each connected with a vertical, rounded, shallow sulcus. M'Coy's Fig. 1*a* shows these characters in relief, with the vascular scar central, and Fig. 1*b* the same with an apical scar.‡

As we are not acquainted with either the leaves or fruit of *L. australe*, M'Coy, the only portion of Mr. Carruthers' description of his *L. nothum* with which we are concerned, is the following passage:—"Scars of the leaves contiguous, rhombic, with a single and generally central vascular scar." In his casual remarks the author states that the form of the leaf-scar varies much from pressure, but when not thus affected is rhombic. Two variations are shown in Carruthers' Pl. 26, Figs. 13 and 14.§ The scar of the vascular bundle is generally present, but not always;¶ when present it is sometimes central,‖ at other times apical,** or again gives rise to a "longitudinal impression extending from nearly the bottom to the top of the scar."††

Prof. O. Feistmantel has twice described both *L. australe* and *L. nothum* as separate species, but we need concern ourselves only with the views expressed by his second diagnosis.‡‡ Of *L. australe*, he remarks that the leaf-scars are rhombic, with thick boundaries, the vascular cicatrices small, and oval or rhombic,

* Sedimentary Formations of N. S. Wales, Third Edition—*Mines and Min. Statistics N. S. Wales*, 1875, p. 160.
† W. Carruthers, Quart. Journ. Geol. Soc., 1872, XXVIII., p. 350. The "circulation," by-the-bye, of all but one paper, took place in the same eminently scientific Journal as Mr. Carruthers' paper appeared in.
‡ Prod. Pal. Vict. 1874, Dec. I, t.9, f.1,*a* and *b*.
§ Quart. Jour. Geol. Soc., 1872, XXVIII, p. 353. The question of the identity of *L. nothum* with *L. gaspianum*, or *Leptophlæum*, having no bearing on the present discussion, is not referred to here.
¶ Carruthers, *loc. cit*. Pl. 26, Fig. 12.
‖ Carruthers, *loc. cit*. Pl. 26, f. 10.
** Carruthers, *loc. cit*. Pl. 26, f. 8 and 11.
†† Carruthers, *loc. cit*. Pl. 26, f. 9.
‡‡ Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3, p.p. 136–138.

rarely near the middle, more commonly at the upper angle of the scar, with a shallow median sulcus. Of *L. nothum*, he merely quotes Carruthers' description.

The foregoing are simply facts derived from each author; we may now enter on the points for and against the identity of these two supposed species. The evidence is simply taken from their descriptions, my own observations made from the specimens now in our Collection being left until later. One point, however, must be clearly understood—none of the present remarks are intended to apply to *Lepidodendron nothum*, Unger, the European fossil, but simply to *L. nothum*, Carr., the supposed Australian plant.

In the first place the form of the leaf-scar in both is admittedly rhombic, varying slightly in degree, according to the amount of pressure the plant had undergone; and both M'Coy and Feistmantel agree in describing that of *L. australe* as with straight thick boundaries, which are also visible on some of Carruthers' figures of *L. nothum*.* The vascular scar in both is single, central or apical in *L. nothum* (Carruthers); near the middle, or towards the upper angle in *L. australe* (M'Coy); rarely near the middle, but more often towards the upper angle in *L. australe* (Feistmantel); and in *L. nothum* the last named author has in contradistinction to Mr. Carruthers, only seen the vascular scars in the upper angles of the leaf-scars. The vascular scars in *L. australe* are often connected with a shallow longitudinal sulcus (M'Coy); showing in the middle a shallow sulcus (Feistmantel) or, in *L. nothum* giving a longitudinal impression extending from nearly the top to the bottom of the scar (Carruthers). Now, the question may be asked, what points of difference between *L. australe* and *L. nothum* does this comparison show? Simply one, viz.:—That in *L. nothum*, Feistmantel has seen the vascular scars only in the upper angles of the leaf-scars; but Carruthers says, that they are central or apical! Yet *L. australe* and *L. nothum* are held to be distinct species. If, therefore, any difference exists between them it must lie in the leaves or fruit, but with neither of these are we acquainted in *L. australe*.

Prof. M'Coy refers his species to that section of the genus *Lepidodendron* known as *Bergeria*, Presl.,† and in this he is followed by Dr. Feistmantel, who quotes the opinion of Prof. Solms-Lauback in support.‡ But Dr. Feistmantel also places *L. nothum*, Carr., in *Bergeria*;§ and from certain remarks make by Mr. Carruthers on the relation of *L. nothum* to Coal Measure *Lepidodendra*, I am inclined to believe that he thought so also.¶ So far, therefore, both so-called species are referred by their respective describers to the same section of the genus. Prof. M'Coy furthermore regards both *L. australe* and *L. nothum*, Carr., as

* Carruthers, *loc. cit.*, t. 26, f. 10 12.
† Prod. Pal. Vict., 1874, Dec., I, p. 37.
‡ Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N. S. Wales, Pal., No.* 3, p. 137.
§ *Loc. cit.*, p. 138.
¶ Quart. Journ. Geol. Soc., 1872, XXVIII, p. 354.

closely related to the European Carboniferous *L. tetragonum*, Sternb. He remarks thus,* "Anyone comparing Mr. Carruthers' or my figures with that of Sternberg's *Lepidodendron tetragonum* . . . will find that the identity is so close, that for what I have figured as a variety or species under the special name *L. australe*, I only suggest the general slightly longer form of the scars as possibly distinctive." And, as a corollary to this, may be quoted his remark, "I do not see any reason for supposing it [*i.e.*, *L. australe*] referable to the little Devonian *Lepidodendron nothum* (Unger)."

Speaking of the *Lepidodendron* previously referred to (*L. tetragonum*) as taken to England by the late Rear-Admiral King, Mr. Clarke says,† "During the last few years I have collected, or received, this plant from a variety of localities in New South Wales and Queensland, and from the latter Colony it was also brought in abundance by Mr. Daintree. Mr. Carruthers, who has given its description fully in the paper before alluded to (Q.J.G.S., August, 1872), has assigned to it the name of a species described by Unger, viz , *Lepidodendron nothum*." Now this is a very important passage, for it proves two things—1st, that others besides McCoy had recognised the resemblance of our Australian fossil to *L. tetragonum*, and 2nd, the identity of *L. nothum*, Carr., with the plant (*L. australe*) likened to *L. tetragonum*, in the estimation of Mr. Clarke. On the other hand, Dr. Feistmantel states, ‡ because *L. australe* is allied to *tetragonum*, therefore the former "can in no way be co-related with *L. nothum*, Ung., from New South Wales and Queensland." It may of course be contended that the opinion of the late Mr. Clarke, through the latter not being a Botanist or Palæontologist, was of little weight in such a discussion; but Mr. Clarke had through long years of training become a very astute observer, and I may therefore, I think, range him on the side of those who failed to see any reason for the splitting of our commonest *Lepidodendron* into two species.

Mr. Robert Kidston takes a very decided view of the mutual relations of *L. australe* and *L. nothum*, Carr. He remarks,§ "The plant figured and described as *Lepidodendron nothum* by Mr. Carruthers (which, however, is not Unger's species of that name) appears to be indistinguishable from *Lepidodendron Australe*, McCoy."

IV.—Notes on Specimens.

I have assembled for examination as many specimens as possible, both from New South Wales and Queensland. The New South Wales localities represented are—Cedar Creek, near Cox's River; Back Creek, Barrington Gold-field; Clear Creek, near Glanmire; Oaky Creek, west of Cobbodah; Goonoo Goonoo, near Tamworth; Boora

* Prod. Pal. Vict., 1874, Dec., I, p. 39.
† Sedimentary Formations of N. S. Wales—Third Edition.—*Mines and Mineral Statistics of N. S. Wales*, 1875, p. 160.
‡ Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N. S. Wales, Pal. No.* 3, p. 137.
§ Cat. Pal. Plants Brit. Mus., 1886, p. 231.

Creek, thirty-nine miles north-west of Tamworth; Doctor's Creek, near Bingera; Tarella Creek, near Barraba; Manilla River, Sowton's Mountain Paddock, near Barraba; Bindogundra, near Bumberg Ranges, west of Molong; Grenfell Road, four miles from Cowra (presented by the Rev. J. Milne Curran). The plants from these, as well as the Queensland localities, including the Great Star River, are of course in various states of preservation, but in a very large proportion the thick boundary ridges of the leaf-scars are visible just as shown in Mr. Carruthers' illustrations, and McCoy's figures of *L. australe*. The rhomboidal leaf-scars are either transversely or vertically elongated, and vary greatly in size, as the following measurements will show:—

Transversely elongated—6 x 4, 4 x 3, 8 x 6, 5 x 4, 6 x 5.

Vertically elongated—4 x 3, 6 x 7, 4 x 3.

Equilateral—6 x 6, 2½ x 2½, 4 x 4.

Out of the seventy odd specimens examined, fifty-seven showed no trace of a vascular scar on the leaf-scar, thus resembling Carruthers' Fig. 12*, and some of those given by Feistmantel,† nor vertical groove or ridge, according as the specimens were reliefs or impressions. Twelve only presented the vascular cicatrix in the upper angle of the leaf-scar, and two alone displayed the vertical ridge extending downwards from the position of the former without its presence.

In the specimens from Corner Creek, Great Star River, the vascular scars are apical, and the leaf-scars transversely elongated with thick margins.

V.—Comparison with L. nothum, *Unger.*

Unger's general figure‡ represents a small stem of the natural size, about four inches long, by from three to four-eighths of an inch wide. The leaf-scars vary, as represented on the figure, from one to one and a quarter millimieters, and we are asked to consider the Australian *Lepidodendron*, with its noble proportions as identical with this. In the words of Prof. McCoy, "all the figures of the Devonian species mentioned,§ indicate the much smaller, more numerous, and much more acute, longitudinally elongate leaf-scars as constant characters; together with a central vascular cicatrix." I may add that the latter is the rarest position for the vascular scar to occupy in our Australian species, and as regards the size of the leaf-scars, the measurements previously given speak for themselves. Prof. M'Coy further remarks,‖ "Mr. Carruthers refers a plant from Queensland, which probably is identical with ours, to the Devonian *L. nothum*; but I know of no reason for considering the Gympie beds Devonian; the great balance of the palæontological

* Quart. Journ. Geol. Soc., 1872, XXVIII., t. 26. f. 12.
† Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey, N. S. Wales, Pal. No.* 3, t. 2, f. 1, 2.
‡ Denksch. K. Akad. Wien., 1856, XI, t. 10.
§ Prod. Pal. Vict., 1874, Dec., I., p. 38.
‖ *Ibid*, p. 33.

evidence, in my opinion, indicating rather the Lower Carboniferous age, and, as I have said, of our Victorian plant, I think of the Gympie one,* that the scars are so much larger and fewer on approximately the same sized branches, that it is not desirable to make such a reference."

Again, Sir William Dawson has recently replied to Mr. Carruther's criticisms on certain plants described by him. Speaking of *Leptophlæum rhombicum*, Sir William remarks,† "Some confusion has been introduced into the position of this species by the identification with it on the part of Dr. Carruthers of a very different plant obtained in Queensland by Mr. Daintree. This is perhaps not to be wondered at, since the Queensland plant belongs to a type of Lepidodendron characteristic in America of the Lower Carboniferous, and of which *L. tetragonum* of Sternberg is the representative. This plant had been discovered in the Carboniferous of Victoria by Dr. Selwyn, long before it was found in Queensland, in beds supposed to be Devonian. Specimens from Mr. Daintree's collection shown to me by Mr. Carruthers, and others in the collection of Dr. Selwyn, leave no doubt as to this. . . . . Still further to complicate matters, this Australian *Lepidodendron* was not only identified with *Leptophleum rhombicum*, but with the entirely distinct species *Lepidodendron Gaspianum*, and with *L. nothum* of Unger."

The comparison made, and extracts given, will have prepared the reader for the opinion I have formed, viz., that omitting the question of leaves and fruit, there is no specific difference between *Lepidodendron australe*, M'Coy, and *L. nothum*, Carr. (*non* Unger). If Mr. Carruthers‡ is correct in laying down the axiom, "that the position of the scar, and the presence of a furrow introduced by Dr. Dawson into diagnosis of the genus and species are of no value," how can the two plants be separately retained? No service is rendered to Australian stratigraphical geology by the definite reference of any of its fossils to European species, unless on the clearest possible evidence, and I consider the reference of this widely distributed Australian species to *L. nothum*, Unger, as against the balance of evidence, and committed in the first instance, through an entire ignorance of Australian geological literature.

VI.—The Horizon of L. australe *in Victoria.*

Prof. M'Coy states that *L. australe* is found in the Carboniferous Sandstones of the Avon River, five miles above Bushy Park, Gippsland,§ and it was certainly known to him as early as 1861.¶ Dr. Feistmantel states that the Avon Sandstone

* I think Sir F. M'Coy is wrong here. So far as I know, no *Lepidodendron* has been found at Gympie.
† The Fossil Plants of the Erian (Devonian) and Upper Silurian Formations of Canada, Part 2, 1882 (Geol. Survey Canada, 8vo., Montreal, 1882), p. 105.
‡ Quart. Journ. Geol. Soc., 1872, XXV., p. 352.
§ Proc. Pal. Vict., 1874, Dec., I., p. 39.
¶ Victorian Exhibition Essays, 1861, p. 163.

" rests unconformably on the upturned edges of true Devonian rocks with characteristic fossils."* This statement appears to be taken from Tenison-Woods,† who makes use of exactly the same words, he, in his turn, deriving the facts from M'Coy‡. Selwyn and Ulrich, in describing§ the Avon beds, make no mention of an unconformity between them and the Devonian; nor does Mr. Alfred Howitt, in his masterly paper, "Notes on the Devonian Rocks of North Gippsland," wherein he remarks, ‖ speaking of the Upper Devonian, "We may observe that these conditions continued into the Carboniferous age, and it would seem, as in other parts of the world, with an apparent passage from one formation to the other." Finally, Mr. R. A. F. Murray writes ¶ on this subject as follows:—"From my own observations, I am inclined to believe that the beds in which it [*i.e.*, *L. australe*] is found are among the uppermost of the group, and younger than, though conformable with, the Upper Devonian beds of Freestone and Iguana Creeks. It is highly probable, therefore, judging from their stratigraphical position, that the Avon Sandstones are—as indicated by Professor M'Coy, on palæontological evidence—of Lower Carboniferous age, or passage beds in that direction upwards from the Upper Devonian beds." It may, therefore, I believe, be accepted that *L. australe* is, speaking broadly, of Carboniferous age in Victoria.

VII.—Horizon of L. nothum, *Carr., in Queensland and New South Wales.*

QUEENSLAND.—The first intimation of a Devonian *Lepidodendron* in Queensland is due, so far as I know, to my lamented friend, the late Richard Daintree, C.M.G., although, as I have previously pointed out, not the first announcement of the discovery of the genus in that Colony. It was the plant now known as *L. nothum*, (Unger) Carr. The statement occurs in his "General Report upon the Northern District,"** and the following extracts will pretty well show the unsatisfactory evidence upon which his first opinion was based:—"Next, in the descending order of stratified rocks, are the probable equivalents of the 'Devonian' of English Geologists. . . . . . . The lowest beds in the series are clay-slates and conglomerates, succeeded by massive coralline limestones. The uppermost strata are of a more sandy character. In these upper sandstones the best-preserved fossils are met with. *Lepidodendron* is the chief representative of the flora, associated with a fauna containing in great abundance *Spirifer disjunctus*. As the latter is an Upper Devonian type in Europe, whilst the former ranges from Upper Devonian to the top of the Carboniferous, it would seem to favour the view taken of this formation, and that *Lepidodendron* is here confined to the upper portion of this Devonian series. The slates and limestones of Rockhampton may be taken

* Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N. S. Wales, Pal. No.* 3, p. 137.
† Proc. Linn. Soc. N. S. Wales, 1884, VIII., p. 134.
‡ Prod. Pal. Vict., 1874, Dec., I, p. 38.
§ Phys. Geogr. Geol. and Min. of Victoria—Intercol. Exhib. Essays Vict., 1866., p. 15.
‖ Geol. Survey Vict., Report of Progress, 1876, No. 3, p. 237.
¶ Victoria—Geol. and Phys. Geogr., 1887, p. 67.
** Q'land Leg. Assembly Papers, 1870.

as representatives of the Lower Devonian, and so called "The Rockhampton Series"; . . . . the sandstone and shales of Mount Wyatt, as Upper Devonian, and called "The Mount Wyatt Series." These being provisional, the value of the division to be tested by the careful collection and determination of the contained organic remains hereafter."

On first reading this Report, it is somewhat difficult to grasp to what series of rocks Daintree referred as the "Rockhampton Series." If to the fossiliferous rocks so largely developed around that town, and having for one of their principal localities the Training-wall Quarries on the Fitzroy River, then "careful collection," such as the successful labours of the late Mr. James Smith, will have completely exploded at least a portion of the above classification. The fossils obtained by Mr. Smith have demonstrated the series referred to by me, to be of Permo-Carboniferous age, and identical with rocks of that age so largely developed in New South Wales. But the further context of Daintree's Report does not seem to bear out this idea, rather that, under the above name he included those now regarded by Mr. R. L. Jack and myself as of Middle Devonian age, and distinguished as the Burdekin beds. As regards the association of *Lepidodendron* with *Spirifera disjuncta*, I am of course unable to prove that such is *not* the case in this particular instance, but I think it very *improbable*. During the ten years I have been in the habit of examining Queensland organic remains on behalf of the Geological Survey of that Colony, I have never seen *Spirifera disjuncta* from within its geographical boundaries, much less associated with *Lepidodendron*.

Mr. Daintree continued—"For a hundred miles of longtitude, and forty of of latitude, shales, coralline limestones, and *Lepidodendron* sandstones are repeated again and again at the surface in a series of syn—and anticlinal axes. . . . The only other sedimentary strata in tropical Queensland, whose place on the geological horizon has been determined by palæontological evidence, are a series of blue and grey slates and shales around Mount Wyatt. On the upturned edges of these rest the slightly inclined grits and sandstones of the Upper Devonian *Lepidodendron* beds. Specimens from this locality presented by me several years ago, to the Melbourne Museum, determined by Professor M'Coy, consisted of *Chonetes sarcinulata*, *Orthis* allied to *rustica*, *Receptaculites*, *Lepætna* sp. undetermined; and were referred by that authority to the 'Upper Silurian' of English geologists. The outcrop of these Silurians is very limited round Mount Wyatt."

With regard to the last paragraph quoted, it is clearly perceptible that Daintree did not intend to imply that *Lepidodendron* was associated with the other fossils mentioned. The latter came from the "blue and grey slates and shales," underlying unconformably the Lepidodendron beds, and have been relegated by Mr. R. L. Jack*, and correctly so, I think, to the Burdekin Group. But in connection with

* Handb. Q'land Geology, Col. and Indian Exhib. Essays, 1886, p. 23.

the Lepidodendron beds a peculiar conclusion is forced upon us by this aspect of the case. Litttle doubt can exist that the shales, coralline limestones, and Lepidodendron sandstones, which are "repeated again and again at the surface," are portions of the Burdekin Group; and so are the "blue and grey slates and shales," containing the supposed Upper Silurian fossils named by Prof. M'Coy. If, therefore, the stratigraphy described by Daintree is to be accepted with the light of our present palæontological knowledge, we have Lepidodendron beds unconformable on Lepidodendron beds.

In his Memoir, published two years later, Daintree adds to Mount Wyatt, the further localities of Canoona and Broken River, as those at which *Lepidodendron* is found, and the plant is definitely stated, on the authority of Mr. Carruthers, to be *L. nothum*, Unger, of the European Devonian rocks. Any corroborative evidence of this is certainly not there advanced by Mr. Daintree, notwithstanding the following passage*, "At Mount Wyatt the plant-beds are interstratified with strata containing Spirifers, &c.; and as these are fully described in the Appendices to this paper, no further mention of them is required here." Unfortunately for this statement not a single *Spirifera*, or other Invertebrate, is described from either of the three localities previously mentioned as yielding *Lepidodendron*. On the other hand, there is just the possibility that Mr. Daintree referred to the Gympie Spirifers, then considered Devonian. If so, the case for the Devonian age of *Lepidodendron nothum*, Carr., is made all the worse, because the Gympie fauna is now admitted to be Carboniferous, as suggested both by Prof. M'Coy,† and the late Rev. W. B. Clarke‡ (or more properly speaking, Permo-Carboniferous), an opinion I have held in common with these authorities for some time.

The only evidence known to me, which can be adduced in support of Daintree's reading of the Mount Wyatt geology, is a remark by the late Rev. W. B. Clarke, when speaking of the fossils sent by him to the late Prof. L. G. de Koninck§. "The fossils . . . from Yass, Mount Lambie, and on the Turon and Moruya Rivers, and which are in part identical with the the Mount Wyatt shells in Queensland." On following up this evidence, however, we again meet with disappointment, for on referring to De Koninck's work¶ but a single species is described from Mount Lambie—the only locality in New South Wales where *Lepidodendron* is said to be associated with Devonian fossils—and that is *Rhynchonella pleurodon*, more a Carboniferous than a Devonian shell. Nor are we enlightened on this point in the most recently issued work on Queensland Geology, Mr. R. L. Jack's "Hand-book." On Mount Wyatt, Mr. Jack simply quotes Daintree's remarks from the Northern Report previously given. Of

* Quart. Journ. Geol. Soc., 1872, XXVIII, p. 289.
† Prod. Pal. Vict., 1874, Dec., I, p. 38,
‡ Sedimentary Formations of N. S. Wales. Third Edition.--*Mines and Min. Statistics N. S. Wales*, 1875, p. 159
§ *Ibid*, p. 158.
¶ Foss. Pal. Nouv. Galles du Sud, 1876, Pt. 2, p. 96.

Canoona, he affords no information whatever; but of the Broken River locality, the Queensland Government Geologist observes, "it may be surmised that the Lepidodendron beds occur in a horizon equivalent to that of the Star beds, and separable from the beds which have yielded the corals described by Mr. R. Etheridge, Senior."* Canoona is also referred to by the Rev. W. B. Clarke, who remarks,† "At Canoona Gold Field, in Queensland, Lepidodendron occurs in hardened shales," but not a word about any associated Devonian fauna. Beyond, therefore, Mr. Daintree's statement, that the strata yielding *Lepidodendron* at Mount Wyatt, are interstratified with *Spirifera disjuncta* beds, the presence of a Devonian *Lepidodendron* in Queensland rests on the most contradictory and unsatisfactory statements, unsupported by other evidence. Notwithstanding this we find Dr. O. Feistmantel unhesitatingly committing himself to a Devonian age for the *Lepidodendron*.‡

In December, 1882, the late Rev. J. E. T. Woods brought under the notice of the Royal Society of N. S. Wales, the occurrence of a Flora containing *Lepidodendron* (*L. veltheimianum*), and *Calamites* on the Central Queensland Railway at Bobuntungen, and referred it to the age of the "lower coal formation of Europe," *i.e.*, Carboniferous.§ In the same year Woods recorded also the presence of the disputed *L. nothum* in the same beds, remarking, "It was found on the Drummond Range, at the end of the central railway." || In the stratigraphical portion of his Memoir on the "Coal Flora," he again places these *Lepidodendra* under the Lower Carboniferous, mentioning as localities, "Canoona River, Broken River, and Mount Wyatt." Notwithstanding this, however, the Rev. Author had but a few months before cited *L. australe*, *L. nothum*, and other plants from the Devonian, with precisely the same array of localities.¶

In another publication Mr. Woods speaks of the Drummond Range formation, "which by its fossil plants (Lepidodendron, Calamites), &c., most certainly belongs to the lower Carboniferous of Europe."** Again, a still further expression of opinion was made in August, 1883, in a "Report on Coal on the Central Railway,"†† to the Secretary of Lands, Brisbane, in which, after enumerating the Bobuntungen fossils, he says, "All well known European forms of the lower coal flora." The continued reiteration of his opinion clearly speaks for itself, in so far as the age of these plants is concerned.

* Handb. Q'land Geology, Col. and Indian Exhibition, 1886, p. 41. The corals were described by Prof. H. A. Nicholson, M.D., and R. Etheridge, Jun.

† Sedimentary Formations of N. S. Wales, Fourth Edition, 1878, p. 25, *note*.

‡ Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal.*, No. 3, 137.

§ Journ. R. Soc. N.S. Wales for 1882 (1883), XVI, p. 179.

|| Proc. Linn. Soc. N.S. Wales, 1884, VIII. p. 135.

¶ Journ. R. Soc. N.S. Wales for 1882 (1883), XVI., p. 189.

** The Coal Resources of Queensland, p. 26 (8-vo., Brisbane, 1883).

†† The Queenslander, 1883, XXIV., No. 414, p. 390.

Some years ago Mr. R. L. Jack submitted to me a collection of Carboniferous fossils from the basin of the Great Star River,* a stream formed by tributaries of the Upper Burdekin River. Amongst these were several examples of the so-called *L. nothum*, and since then others have been obtained from the same area by Mr. P. N. Pears, lately Warden of the Ravenswood Gold-field.† Although in the early days of his investigations, the Canoona and Broken River localities,—from whence *L. nothum* was recorded by Daintree, be it remembered—were accepted by Mr. Jack as Devonian, he now seems to think that they may be on the same horizon as the Great Star River beds, and those of the Drummond Range.‡

It will be remembered that the Rev. Mr. Woods recorded *L. nothum* from the Drummond Range, a statement which appears to be accepted by Feistmantel§; at any rate, he does not controvert it. If the species has so preponderating a Devonian significance, its presence at that locality should be allowed to exercise a more or less similar influence, but, on the contrary, the Drummond Range rocks are by one and all set down as Lower Carboniferous.‖

Such appears to be the main distribution of *L. nothum*, Carr, in Queensland, as at present known, the chief points to be borne in mind being—(1) that it does not differ in structure from the *L. australe* of the Victorian Lower Carboniferous; (2) that the balance of evidence points out a similar horizon rather than a Devonian one.

N. S. WALES.—Let us now examine the corresponding distribution of this plant in our own Colony.

I believe the late Rev. W. B. Clarke was the first to apply a name to the N. S. Wales *Lepidodendron*, as *L. tetragonum*, as early as 1851, on the authority of Prof. M'Coy. His words were,¶ "In June, 1851, Professor M'Coy wrote to me from Cambridge, respecting the first Lepidodendron he had seen from Australia, and which I had forwarded by the late Rear-Admiral King to Professor Sedgwick, and stated it to be *L. tetragonum* of the English coal-fields." He added likewise, "During the last few years I have collected, or received, this plant from a variety of localities in New South Wales and Queensland, and from the latter Colony it was also brought in abundance by Mr. Daintree." In an earlier edition of the Memoir from which these extracts are taken, Mr. Clarke spoke as follows on the general question:—"So far as Lepidodendron is concerned, that plant occurs in some places in association with beds that are decidedly younger than any called

* Report on the Geology and Mineral Resources of the District between Charters Towers Gold-fields and the Coast, by R. L. Jack, p. 10 (fcap, Brisbane, 1879).
† Jack, Handb. Q'land Geology, Col. and Indian Exhib., 1886, pp. 39 and 40.
‡ Handb. Q'land Geology. Colonial and Indian Exhib., 1886, p. 40.
§ Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., 1890—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3, p. 138.
‖ *Loc. cit.*, p. 55.
¶ Sedimentary Forms. N.S. Wales. Third Edition.—*Mines and Min. Statistics N.S. Wales*, 1875, p. 160.

Devonian, near Pallal, on the Horton River, and on the Manilla River, in Liverpool Plains. . . . . . and at Goonoo Goonoo, on the Peel River, in New South Wales, it occurs in fine grey sandstone with Ferns and Sigillaria, in close proximity to beds of marine fossils which are certainly Lower Carboniferous."* The localities here mentioned will be found in Pars. I. and IV., as amongst those at which *L. nothum.*, Carr., has been found, so that no doubt can exist as to the species referred to by Mr. Clarke. The Rev. Gentleman appears to have been the first in 1875 to record *L. nothum*, by name, as a New South Wales fossil, and to show its extent over a wide area.† His remarks were, "During the last few years I have collected, or received, this plant from a variety of localities in New South Wales." The only locality mentioned by name is the Mount Lambie Range, near Rydal, "where the Devonian Brachiopoda occur." In 1878, Dr. Feistmantel added two further localities, Goonoo Goonoo, on the Peel River, and the Back Creek Diggings, Barrington River.‡ In the Fourth Edition of the "Sedimentary Formations," Clarke supplemented the above important statement by announcing that in 1876-77, he had ascertained the position of *L. nothum*, Carr., to be considerably below the Brachiopod Sandstone of Mount Lambie.§ On the other hand, Mr. C. S. Wilkinson places ‖ the Lepidodendron bed above the sandstone with Brachiopoda. In 1882 he wrote as follows:—"The lower beds, which form the summits of Mount Walker and Mount Lambie, consist of sandstones and quartzites with numerous fossils, chiefly *Spirifer disjunctus*, and *Rhynchonella pleurodon*; while above these are shales, slates, and quartzites containing *Lepidodendron nothum*." This statement was repeated in the second edition of the "Notes"¶ published in 1887. The other and unpublished localities at which *L. nothum*, Carr, has been obtained in New South Wales, and of which specimens are extant, will be found in Par. IV. In the English edition of his "Palæozoic and Mesozoic Flora of Eastern Australia," Dr. Feistmantel gives as further localities for *L. nothum*, Carr., Cowra and Canowindra, on the Lachlan River; and, relying on Mr. Clarke's account of the Mount Lambie deposits, considers the plant wholly of Upper Devonian age. To his remarks the following editorial foot note was appended in the work just quoted,** "The passage referred to here in Mr. Clarke's 'Sedimentary Formations of New South Wales' is, on the first reading a somewhat misleading one. The expression 'below the level,' must not be taken in a stratigraphical sense, but simply as indicating a lower position as regards the conformation of the ground. The Government Geologist distinctly wishes it to be understood that the *Lepidodendron* in question occurs in beds *above* the Brachiopod Sandstone of Mount

* Sedimentary Forms. N.S. Wales. Second Edition.—*Cat. Nat. Industrial Prods. N.S. Wales, Paris Univ. Exhib.*, 1867. *App.* p. 71. (8vo., Sydney, 1867.)
† Sedimentary Forms. N.S. Wales. Third Edition.—*Mines and Min. Statistics N.S. Wales*, 1875, p. 160.
‡ Pal. Mes. Flora Ost. Australiens.—*Palæontographica*, Suppl. Bd. iii, Leif 3, 1879, Heft. 4, p. 142.
§ Sedimentary Forms. N.S. Wales. Fourth Edition, 1878, p. 22.
‖ Notes on the Geology of N. S. Wales (Dept. Mines, N.S. Wales), 1882, p. 42.
¶ Notes on the Geology of N.S. Wales. Second Edition. (Dept. Mines, N. S. Wales), 1887, p. 57.
** Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3., p. 36 *note.*

Lambie, he having been present with the late Rev. Mr. Clarke when the observations were made. . . . . ." This is confirmed by another short description of Mount Lambie given by Mr. Wilkinson* in 1875, wherein he states that the Lepidodendron beds are about one hundred feet thick, and occur one thousand feet above the Spirifer Sandstone. Now, admitting the latter to be Devonian, the only point which tends to place the Lepidodendron beds within the same formation is the conformability of the latter to the former, although at a height of one thousand feet above. But is this of greater importance than the equivalent conformability which exists between the Upper Devonian beds in Gippsland and the Avon Series with *L. australe*, which are admittedly Carboniferous?

On a previous page a quotation was given from Mr. Clarke's writings, in which he refers to the association of *Lepidodendron* with beds "decidedly younger than any called Devonian," such as the Manilla River; and at Goonoo Goonoo, "in close proximity to beds of marine fossils which are certainly Lower Carboniferous." A reference to Par. IV, containing a list of the localities from which we now possess *L. australe*, will show that both of these are there included, and herein we have additional evidence for the Carboniferous age of the *Lepidodendron* in question. The reference to Goonoo Goonoo is the more important because Dr. Feistmantel has made the following statement† in connection with the so-called *L. nothum*, Carr:—"According to the available literary sources, this fossil comes from beds which have to be considered of Upper Devonian age, at least with regard to the geological sequence in New South Wales, where the Goonoo beds underlie the *Lepidodendron* beds of Smith's Creek, Stroud, which themselves are Lower Carboniferous."

That the Smith's Creek plant-beds may be of the age mentioned is, I think, probable; but I must confess myself entirely ignorant of the literary sources from which the position of the Goonoo Goonoo beds is deduced. Little or nothing seems to be known of their definite relations to the surrounding rocks, and even Mr. D. A. Porter, of Tamworth, who has long studied the geology of that district, assured me that he had failed, so far, to solve the question.

VIII.—Conclusion.

In the foregoing summary of the facts relating to *L. australe*, M'Coy, and *L. nothum* Carr. (non Unger), I have endeavoured to bring forward all the information relating to the age of these plants within my power, whether for or against the Devonian hypothesis. The facts which have been advanced from time to time to sustain this seem to be inadequate for the purpose—simply with our present knowledge, be it understood—and I think it will be better to suspend judgment until more is known of the geology of the districts in question.

* Mines and Min. Statistics of N. S. Wales, &c., 1875.—*N. S. Wales Intercolonial and Philadelphia Internat. Exhib.* (8vo., Sydney, 1875), p. 133.

† Coal and Plant-bearing Beds of Palæozoic and Mesozoic age in E. Austr. and Tas., &c., 1890.—*Mem. Geol. Survey N.S. Wales, Pal. No.* 3, p. 138.

If the conformable transition described by Mr. Howitt, between the Upper Devonian and Carboniferous of Gippsland is of general occurrence throughout Eastern Australia, it will perhaps be convenient to adopt the presence of this *Lepidodendron* as the artificial line of demarcation between the two great series which are presumed to represent portions of the Devonian and Carboniferous Formations of other parts of the world. On the other hand, it is of course possible that a detailed survey of the Mount Lambie and Mount Wyatt areas in New South Wales and Queensland respectively, may show that the Lepidodendron beds are an integral part of the Devonian series there said to exist. In such a case *L. australe* can only be looked upon both as a Devonian and Carboniferous species, for it most certainly occurs with a Carboniferous fauna in the Great Star Basin in Queensland (see Par. IV). But, presuming that such be the case at Mount Lambie, the latter occurrence only shows how preposterous it is to assume that Devonian rocks exist at every locality from which the species is quoted under the misapplied name of *L. nothum*, Unger, when practically nothing is known of their detailed geology. The preparation of comparative tables of Australian Stratigraphy on such evidence as this is not only of doubtful value, but is also misleading. Indeed, I think I may cite this question as evidence strongly in favour of the remarkably philosophical arguments used by my friend Mr. R. M. Johnston, in his paper on "The Order of Succession of the Characteristic Genera of Fossil Plants of a Far Distant Region, &c.,"* in which he pleads against the belief that the community or resemblance of organic remains in rocks of far distant regions indicates strict contemporaneity, and I believe, in a broad general way, with great success.

The following deductions can, I think, be drawn from the remarks made in previous pages:—

1. A *Lepidodendron* occurs in Victoria, N. S. Wales, and Queensland in beds either of Upper Devonian or Lower Carboniferous age, or both, specifically identical.

2. Of the two names applied to this species, *L. australe*, M'Coy, in Victoria; and *L. nothum*, Carr., in N. S. Wales and Queedsland, the former should be adopted.

3. *L. australe* appertains to the section *Bergeria*, and is allied to *L. tetragonum*, Sternb., of the European Coal-Measures.

4. The horizon of this plant in Victoria is generally accepted as Carboniferous.

5. *L. australe* occurs in the basin of the Great Star River, Queensland, associated with a Carboniferous fauna.

* Proc. Austr. Assoc. Adv. Sci. for 1888 [1889], I, p. 302.

6. The Drummond Range rocks, in which this plant is said to occur by the late Rev. J. E. T. Woods, are Carboniferous.

7. With the exception of Mount Lambie in N. S. Wales, and Mount Wyatt in Queensland, no direct evidence exists for considering the beds developed at the various localities as Devonian.

8. The evidence for assuming a Devonian age to the Mount Wyatt beds containing *Lepidodendron* is as present unconfirmed, and unsatisfactory.

9. At Mount Lambie there appears to be an insensible gradation, *so far as our present knowledge shows*, from beds of Upper Devonian age into those of Lower Carboniferous, as in Victoria.

10. We have no tangible evidence of the commingling of a *Lepidodendron* and a Devonian fauna, as we have of *L. australe* and a Carboniferous at the Great Star River.

11. The resemblance of *L. australe* to a European Coal-Measure species, *L. tetragonum*, Sternb., and a Lower Carboniferous American form, as noted by Dawson, and related to *L. tetragonum*, is strong presumptive evidence of the Carboniferous age of the first-named, supposing, *i.e.*, we are to adopt, or endeavour to adopt, a European classification for our Upper Palæozoic rocks.

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. II.] 1892. [Part 4.

XX.—Notes on Experiments with the Munktell Chlorination Process at Bethanga, Victoria: by E. F. Pittman, Assoc. Royal School of Mines, L.S., Chief Mining Surveyor.

ERRATA.

Vol. I, P. 3.

Page 94, line 5—For *insolubility*, read *solubility*.

Page 94, line 6—For *not to differ*, read *differ* (deleting *not to*.)

The process is essentially a chlorination process, and consists of (1) calcining the ore in heaps in the open air; (2) crushing in a rock-breaker; (3) pulverising in the dry state; (4) roasting with or without salt; (5) leaching in closed vats with hot water, collection of the water containing the copper in solution, and precipitation of the copper by means of scrap-iron; (6) treatment of the ore in the same vats

with dilute sulphuric acid to remove the suboxides of iron, etc.; (7) treatment in the vats with chlorine under pressure, and collection of the liquor containing the gold in solution; (8) precipitation of the gold with sulphate of iron; (9) collection of the precipitated gold, smelting with litharge, and cupelling.

The ore as it comes out of the mine is stacked in heaps over wood, and the latter ignited. The heaps are allowed to remain until combustion of the sulphur and arsenic ceases. The ore is then crushed to small lumps in a rock-breaker from which it passes to a dry crusher, with gratings containing about one hundred and forty-four holes per square inch. The pulveriser at present in use is not altogether satisfactory, and it is proposed to use globe mills for the purpose. The pulverised ore is then roasted in a reverberatory furnace with an inclined hearth. The furnace in use is forty-four feet long and four and a half feet wide, and will roast about three tons per twenty-four hours. Two quantities, with and without salt respectively, were roasted in this furnace during my visit, and the results appeared to be equally satisfactory.

There is no doubt that in view of the experiments made by Professor S. B. Christy, in America, the use of salt in roasting auriferous ores is objectionable by reason of the volatility of the chloride of gold formed. In a paper read in May, 1887, before the American Institute of Mining Engineers, Professor Christy shows that in roasting with salt a loss of 30 per cent of the total amount of gold can easily result, and although the actual loss of gold in the nineteen tons roasted in my presence only amounted to 1·15 per cent., I have no hesitation in saying that the use of salt is too risky to be recommended.

The temperature, when roasting with salt, is kept low, the sulphur just burning, and the charge meets a slightly increased heat at the finish as it approaches the bridge of the furnace. The roasting is known to be finished when a sample of the ore is found to contain no more sulphides of copper or iron. The test for the former is made by boiling some of the samples in dilute acid, washing and decanting several times with hot water, then dissolving the residue in nitric acid, and adding ammonia, when the absence of blue colouration is proof that all the sulphide of copper has been decomposed by the roasting. Sulphide of iron is decomposed sooner than sulphide of copper, and is therefore not likely to be present if the latter be absent. It may, however, be tested for by heating a sample of the roasted ore with dilute acid in a test tube and holding over the latter a piece of filter-paper saturated with a solution of acetate of lead. A blackening of the paper denotes that the roasting has not been carried far enough.

The roasted ore while still somewhat hot is conveyed by trucks to the works, and is transferred by shoots to the vats. The vats at present in use at Bethanga, are made of wood and lined with lead. They are circular in section, and are

slightly wider at the bottom than at the top. They are strongly made and are strapped with iron. The covers are of cast-iron, and are screwed down upon a ring of indiarubber to render them airtight. A false bottom is placed in each vat to prevent clogging, and insure regular percolation, through the ore, of the liquids which enter the bottom of the vat through a pipe. Pebbles, covered by a perforated sheet or disc of lead, were used as a temporary substitute for a false bottom at Bethanga. Just above the false bottom is the man hole, through which the tailings are discharged after the process is finished. The man-hole is closed by a lead-lined iron door, which is fastened airtight by a screw. A second or exit pipe leaves the vat near the top, and through this the liquids escape after the leaching. The end of this pipe, inside the vat, is furnished with a rose formed of fibre matting or asbestos cloth, to prevent any of the finely-powdered ore from being carried out of the vat. A small branch tube leading from the exit pipe enables a sample of the liquids coming from any vat to be drawn off and tested at any time Both the entry and the exit pipes can be stopped or opened by means of clips or stop-cocks. It is probable that in the event of large works being established, the vats will be made of iron (lined with lead), or of earthernware, and of three tons capacity each. Those at present in use hold about half a ton each, and there are sixteen of them arranged in a circle. They are numbered and can be connected in numerical or any other order by means of hose pipes.

Elevated about ten feet above these vats is a platform upon which stands a vat of hot water (heated by means of steam), a vat for holding dilute sulphuric acid, and a vat for solution of bleaching powder (chloride of lime). These vats are of two hundred and fifty gallons capacity, but in the case of a large plant they would be correspondingly larger. The elevation of the platform upon which these vats stand, enables their contents to enter the chlorination vats under the pressure of about half an atmosphere.

The chloride of lime, or bleaching powder, is placed along with some pebbles in a perforated barrel, which revolves when partly immersed in the water in the vat. The solution of bleaching powder thus made leaves the vat by a pipe which meets another pipe from the sulphuric acid vat. The two liquids (acid and chloride of lime) when being used are only allowed to mix just as they enter the chlorination vats.

Vats, numbered 1 to 4 are first connected, and hot water is allowed to enter No. 1 from the bottom while the ore is being charged through the top.

The cover is then screwed down, and the same process is gone through with Nos. 2, 3 and 4. The exit pipe from No. 4 vat is now connected with a copper precipitating vat and hot water is allowed to flow through the four vats for a period of about nine hours or until the washings contain only traces of copper. The

chloride and sulphate of copper formed in the ore during roasting are thus dissolved and removed, and the copper is then precipitated from this solution (heated to 150° Fah. by means of a steam pipe) by scrap-iron, while the sulphate of iron resulting is used subsequently as a precipitant for the gold.

The hot water pipe is now removed from No. 1 vat to No. 5, and Nos. 5 to 8 are subjected to leaching with hot water while a pipe containing hot dilute sulphuric acid is attached to the inlet of No. 1 vat, and Nos. 1 to 4 are leached with acid for about nine hours. The strength of the acid varies according to the quantity of copper in the ore. With the Bethanga ore about twenty five litres of strong acid (specific gravity 1·75) are used with two hundred and fifty gallons of water. Vats Nos. 1 to 4 are now again treated with hot and finally with cold water until the washings give no reactions for suboxides with permanganate of potash.

The above processes are, in the same order, being alternately applied to each series of four vats in the circle. Only the first washings are allowed to flow into the copper precipitating vat, the subsequent washings being allowed to run to waste. When the first four vats have been completely washed the connections are opened and the vats allowed to drain. They are then again connected, and to the inlet pipe at the bottom of No. 1 vat is attached the pipe conveying the mixture of sulphuric acid and chloride of lime solution. The outlet pipe from No. 4 conveys the resulting solution of chloride of gold into a five hundred gallon lead lined tank, where the gold is subsequently precipitated.

The chlorination lasts about three days. As soon as a sample of the liquid, taken from the outlet test pipe of No. 1 vat, shows no reaction for gold with protochloride of tin and hydrochloric acid, the chlorine solution pipe is detached from the inlet of No. 1 and attached to No. 2, while No. 5 vat is connected with No. 4, and the solution of chloride of gold is then drawn from the outlet pipe of No. 5. The contents of No. 1 vat are then leached with water to remove the chlorine. This vat is then uncovered and the tailings are sluiced out of the manhole by means of a water-hose, and are run down shoots to the waste heap. As soon as each vat is emptied it is refilled with fresh ore.

By having the chlorinating vats arranged in a circular system the above described processes can be continuously carried out, and successive vats utilised for the various stages of the process.

Silver is not present in the Bethanga ore in sufficient quantity to render its extraction profitable.

The solution of gold from the chlorinating process is collected in five hundred gallon vats (lead lined), and is there heated to a temperature of 150° Fah. by means of steam. About twelve buckets of sulphate of iron solution from the copper-precipitating vats are then poured in, and the vats allowed to stand for

some hours. The permanganate of potash test is used to ascertain when a sufficiency of sulphate of iron has been added. When the precipitated gold has thoroughly subsided the supernatant liquor is drawn off by a syphon, the gold is collected, heated with sulphuric acid (to dissolve the bulky white precipitate of basic sulphate of iron with which it is mixed), thrown on a filter, dried, smelted with litharge, soda, and borax, and the resulting lead is cupelled.

About five and one third tons (11,984 lb.) of ore were treated by the wet process in my presence. This required 96½ lb. of strong sulphuric acid to make the acid solution for leaching, and the chlorinating consumed 63½ lb. of strong acid, and 71 lb. of chloride of lime. This ore, before roasting with salt, contained by assay 1 oz. 14 dwt. 7 gr. of gold, 1 oz. 3 dwt. 9 gr. of silver per ton, and 0·82 per cent. of copper.* After roasting, and when put into the vats, it contained by assay 1 oz. 12 dwt. 16 gr. of gold, and 1 oz. 2 dwt. 20 gr. of silver per ton. It also contained 2·65 per cent. of sulphur (of which 2·44 was present in the state of sulphates, the balance 0·21 consisting of sulphides) and 1·21 per cent. of arsenic.

The contents of one vat after chlorination were dried and weighed, and were found to have lost 10 per cent. of their original weight during the wet process.

These tailings yielded by assay 7 dwt. 8 gr. of gold, and 1 oz. 2 dwt. 2 gr. of silver per ton, and 0·17 per cent. of copper. 20·2 per cent. of the total amount of the gold contained in the ore before chlorination were, therefore, left in the tailings. When the gold had been precipitated, dried, and smelted with litharge, it was found that the resulting alloy contained a large percentage of arsenic, and owing to an unfortunate accident with the crucible while remelting the impure lead with nitre, a considerable quantity of the gold was lost in the furnace, and I was, therefore, unable to compare the weight of gold actually extracted with the amount left in the tailings. In practice this method of precipitating with sulphate of iron, smelting with lead and cupelling, will no doubt give place to the much simpler process of precipitating the gold directly from the chlorine solution by charcoal and then burning the latter in pans. It is impossible to free the ore entirely from arsenic, even with the most careful roasting, and a small fraction of an unit per cent. in the ore will be sure to give a considerable amount of trouble in cupelling where the sulphate of iron method of precipitation is used as described above, while in the separation of the gold by charcoal filters no inconvenience would be experienced from the arsenic.

The amount of gold left in the tailings (7 dwt. 8 gr. per ton, or 20·2 per cent. of the total gold) is unquestionably too high. There is very little doubt that it is due in great part to the impure chloride of lime used. A sample of this substance, on being analysed by Mr. Dury, was found to contain only 14 per cent. of feebly combined chlorine, whereas it should contain over 30 per cent. The amount of

* Most of the assays quoted in this paper were made by Mr. J. C. H. Mingaye, F.C.S., Analyst to this Department.

sulphuric acid to be used with the chloride of lime in the process is determined by calculation, and is intended to be just sufficient to release the feebly combined chlorine. It is probable, therefore, that as the bleaching powder contained so much less than the normal quantity of chlorine, the acid used was correspondingly in excess of the necessary quantity, with the result that sulphate of iron was formed in the vats, and the solution of some of the gold thereby prevented. I do not think, therefore, that the process can be fairly judged by the amount of gold left in the tailings in this instance. With better chemicals I should expect the results to be very much improved with a corresponding reduction in the cost.

The following is, I think, a liberal estimate of the cost of treating the ore :—

	£	s.	d.	
Calcining in heaps	0	2	0	per ton of ore*
Reduction in rock-breaker	0	1	0	„
Pulverising	0	2	0	„
Roasting	0	11	3	„
Cost of chemicals at present price	0	12	0	„
Labour for chemical process	0	2	0	„
Laboratory reagents, steam for heating vats, smelting gold, &c.	0	1	6	„
Depreciation of plant (say)	0	3	0	„
	£1	14	9	„
Add cost of raising the ore	1	5	0	„
Transport of ore to works	0	3	0	„
	£3	2	9	„

Properly conducted the process should extract at least 90 per cent. of the gold, and assuming that the ore contains an average of 1 oz. 5 dwt. per ton, this would be worth (say) £4 10s., so that there should be a profit of at least £1 7s. 3d. per ton. The value of the copper extracted must also be added to this.

The item "cost of chemicals, 12s." is based on the present prices of sulphuric acid, chloride of lime, and salt delivered at Bethanga, which are as follow, viz.:—

Sulphuric acid	£20 per ton.	+	£3 18s. + 10s.	carriage	=	£24 8s. per ton.
Chloride of lime	£19 „	+	5s. + 10s.	„	=	£19 15s. „
Salt	£5 „	+	5s. + 10s.	„	=	£5 15s. „

By making large yearly contracts, however, these prices could, I understand, be reduced nearly 25 per cent.

The roasting could also, probably, be more economically performed if a mechanical furnace were employed, such, for instance, as that designed by Mr. Merton, and used at the Clyde Smelting Works. This furnace appears to be both economical and efficient, and with it there is a very small amount of loss from dust.

* Raw ore—as mined.

The chief merits of the process are (1) the fact that practically an unlimited number of vats can be worked continuously on the circular principle, the various stages of the process being carried on simultaneously; (2) there is no waste of chlorine, and consequently no unhealthy effect upon the workmen, the reason of this being that the chlorine is forced through a series of vats and has practically no means of escape; (3) the progress of the process can be readily tested at each stage, so that the foreman can always know the exact time at which the next step should be taken.

The cost of the process may appear high when compared with the economy claimed for some of the barrel chlorination processes, or the M'Arthur-Forrest Process, but the presence of copper in the Bethanga ore would be a difficulty in the way of the former, and the latter has not yet been satisfactorily demonstrated in these Colonies, so far as I know.

It appears to me that the process introduced by the Metals Extraction Company is well adapted for the treatment of the Bethanga ore, but there are few mines in New South Wales where similar conditions obtain in regard to the quality and quantity of the ore, and the occurrence of a good supply of pure water which is requisite for the process.

XXI.—On the General Geology of the South Coast, with Petrological Notes on the Intrusive Granites and their Associated Rocks around Moruya, Mount Dromedary, and Cobargo: by WILLIAM ANDERSON, Geological Surveyor.

[Plates VIII-X.]

I.—General Geology.

THE country immediately bordering the sea coast in the Southern District consists of comparatively small, isolated outcrops of granite, surrounded, and separated from each other, by a series of Palæozoic sedimentary rocks, which have a general northerly strike, except in close proximity to the granitic areas where the intrusions of the latter have produced local variations in the dip of the beds. The higher portions of the main coastal range consist of granite, which in the latitude of Bega extends as a continuous outcrop almost to the coast.

The sedimentary rocks on the coastal side of the main range, among which the granitic intrusions have taken place, consist of thin bedded argillaceous slates, with sandstones and, in a few localities, lenticular beds of limestone of no great thickness or extent. In many places they contain auriferous reefs, a few of

which have returned fairly good prospects. In various localities, their denudation has shed large quantities of alluvial gold. At Nerrigundah almost the entire alluvial deposits filling the lower parts of the valleys have been turned over, and have yielded tons of gold. So far as has yet been discovered, these strata are almost entirely destitute of organic remains. The only locality in which fossils have been detected is in the limestone at Bendithera, about forty miles west of Moruya. During a recent visit to this locality I was fortunate enough to discover in the limestone referred to a thin band which is very rich in individual specimens of one genus of coral. My colleague, Mr. R. Etheridge, Junr., Palæontologist, who has examined them, informs me that they belong to the genus *Favosites*, and are probably Upper Silurian. Because of the great scarcity of fossils from this district, it is uncertain as yet to what age the strata belong, nor is there any satisfactory data to fix their stratigraphical relations to the Palæozoic rocks of the Monaro tableland on the western side of the main range. All that can be said concerning them is that they are probably of Upper Silurian age.

In various parts of the district outliers of nearly horizontally bedded Devonian conglomerates, sandstones, and shales occur, resting unconformably on the Silurian rocks, and in rare instances overlying the granites, which, however, have not intruded them. They generally form a capping to approximately north and south ridges, which occur among the higher portions of the coastal range, where they are present at intervals along a narrow belt of country stretching from Wyanbene, about forty miles west of Moruya, through Nerrigundah or The Gulph, the Black Range near Bega and Wolumba, to near Eden. In many parts of the district these denuded outliers, which often extend for miles in one direction, but are always narrow, have been mistaken by experienced miners for a cemented wash representing the bed of an old river-course, and consequently a considerable amount of useless prospecting work has been done in their vicinity, but of course with no result other than traces, or colours of gold. The presence of gold in these Devonian conglomerates would, however, show that gold-bearing reefs probably existed in the Pre-Devonian rocks from whose denudation the Devonian conglomerates were formed. The presence of marine fossils in similar horizontally bedded Devonian outliers occurring between Cobar and Wilcannia would serve to indicate that probably the Devonian rocks in this district are also of marine origin, they being hardly distinguishable petrologically and in their mode of occurrence from those on the Darling. In a north-westerly direction from this part of the coast isolated outliers of this formation are met with right up to the Queensland and South Australian borders, giving evidence of the enormous area in this Colony over which the Devonian formation was at one time developed.

The newer deposits which locally cover the Palæozoic sedimentary and intrusive rocks consist of Tertiary, Pleistocene, and Recent Alluvial accumulations. These are for the most part of fresh water or lacustrine origin, but stretching from the

Wagonga River northwards at least past Mogo, north of Moruya, occurs an alluvial deposit averaging over a mile in width and of considerable thickness, which may possibly be marine. Judging from its height above sea level, and its relation to the newer alluvial deposits, it is certainly in its origin anterior to the Pleistocene alluvials in the valleys, and may possibly be of Tertiary age. It rests locally both upon the granite and the slates, and consists chiefly of siliceous pebbles of all sizes, cemented in places and carrying traces of gold. It never occurs further inland than a few miles from the present coast line, and it is not now continuous, having been denuded locally during the excavation of the present valleys.

The Pleistocene and Recent Deposits, forming extensive flats in the valleys and on the shores of the lakes, consist chiefly of the detritus carried down by the creeks.

Besides the Post-Tertiary deposits formed by geological agents, somewhat extensive accumulations occur which have been brought together by the agency of man, and therefore date within the human period. These are the shell-heaps or Kitchen-middens which are to be found on the shore-lines of almost every inlet, lake, and river estuary along this part of the coast. They have been described in a previous Paper.*

The physical features of this coast are of the usual littoral type. The immediate coast-line is mostly formed of slate rocks, which at intervals have been worn into cliffs of considerable height, in which many caves, few of them of any extent, have been hollowed out by the action of the waves. Those portions of the coast-line which consist of granite are generally low-lying, and form long stretches of sandy beach dotted here and there with large boulders of granite. The coast in the neighbourhood of Tathra consists of an intrusive prophyry. The whole coast is indented by large numbers of extensive and irregularly formed salt water lakes, which are generally closed by sand banks except during periods when the rivers which enter their inland ends are in flood. These lakes, like Sydney Harbour and Botany Bay, were probably originally land valleys which have since been depressed below sea level. The whole coastal area is of a slightly undulating character, and the only elevation of any great height is Mount Dromedary.

Further inland towards the Monaro Tableland the general level of the country rises rapidly and becomes very mountainous and rugged, forming the main coastal range.

II.—The Granites.

The three areas occupied by granite on this part of the coast occur around the following centres:—Moruya, Mount Dromedary, and Cobargo. In general characters the rocks are much alike, their main masses being hornblendic and micaceous granites, containing light grey coloured felspars. Associated with the Mount

* Records Geol. Survey New South Wales, II., Pt. II., p. 52.

Dromedary granite, however, two small areas of granite occur at the Little Dromedary which are widely different from the typical rock composing the mountain proper. The one is largely porphyritic by flesh coloured felspar, and the other is a rare form of granite containing little quartz, but characterised by the abundant presence of augite as an essential constituent. This augitic rock has no doubt some connection with the augite-felspar-mica rock referred to hereafter as occurring on the coast, and on the west side of the mountain.

(*a*) MORUYA GRANITE.—The Moruya granite has a somewhat circular outcrop about eight miles in diameter. The town of Moruya is situated near its centre. Eastward towards the mouth of the river it extends to within a mile of the sea opening, while to the westward it junctions with the slate rocks within four miles of the town. On the left bank of the river below the town it has been quarried for building and ornamental purposes. It is of a greyish colour, takes a high polish, and possesses a uniformly moderate sized crystallisation. In numerous places it has been intruded by quartz-porphyry dykes. Its utility for decorative building purposes is somewhat marred by the presence of dark coloured patches, which are occasionally of considerable extent and occur in great numbers throughout the rock, in fact the faces of the quarries are quite spotted over with them. In many cases they are undoubtedly segregations of mica and hornblende, perhaps formed from the residual magma after the general mass had crystallised. In other cases there is every reason to believe that they have been fragments of foreign rocks caught up by the intrusive mass during its passage through the strata which it has intruded. The weathered surfaces of these latter have the appearance of boulders in a conglomerate or agglomerate, some of them being quite angular. One such mass consisted entirely of crystalline quartz, which had not been crystallised in a cavity as a secondary mineral, but whose crystallisation had evidently been induced by the heated fluid magma in which it had been caught up. Many of these dark patches present a distinct lamination which may represent the original sedimentation lines or a secondary schistose lamination produced by the pressure of the enclosing granitic rock-mass.

I quote here an analysis of this granite given by Prof. A. Liversidge in his Minerals of New South Wales.*

Sp. Gr. 2·678 at 21° C.

Hygroscopic moisture at 100° C.	·168
Silica	67·557
Alumina	16·391
Iron sesquioxide	1·246
Iron protoxide	1·858
Manganese protoxide	·794
Lime	5·075
Magnesia	1·484
Potash	1·770
Soda	3·540
	99·883

* P. 224.

(1.) *Micaceous or Hornblendic Granite.*—Microscopically it is a grey granite and is never largely porphyritic. As a rule it is of moderate texture, but it differs locally, some portions of the outcrops being finely crystalline. The mica and hornblende are generally evenly distributed through the rock, but in some places the chief minerals are quartz and felspar, the former predominating. This usually occurs in the immediate neighbourhood of the finely crystalline segregations of mica and hornblende.

Microscopical Characters.—The typical rock is represented by *Slide No.* 293 which shows a moderate crystallisation. It consists of triclinic felspar, quartz, mica, and hornblende with apatite microliths. The triclinic felspars are slightly porphyritic, and are generally clouded. Usually the opaque material is confined to the centre of the felspar individual, this kernel being surrounded by clear felspar, which is probably of secondary origin. Many of the felspars contain a central twinned crystal of triclinic felspar, surrounded by a peripheral felspathic zone, each of which polarises independently of the other. The central crystal has its angles usually rounded as if it had undergone a certain amount of corrosion, and from the way in which the edges of the peripheral zone are indented by the surrounding minerals, it is evident that the latter zone is of secondary growth. There are other evidences, in most of the felspars, of secondary growth. The dividing lines between the primary and secondarily formed felspar are marked off by rows of minute rounded quartz grains, which have certainly been originally individuals of primarily crystallised quartz, subsequently surrounded by the secondary growth. This feature is quite characteristic of this section (Pl. X, Fig. 1). The quartz is very irregular in outline, is usually in minute grains, and speaking generally, is more abundant than is the case in the granite of Mount Dromedary. The mica is in small light coloured plates having frayed edges. The hornblende is green, contains many inclusions, and shows the characteristic cleavages. The two latter minerals are about equally abundant. Apatite microliths are very minute and do not occur very frequently.

Slide No. 294 is a finer grained variety, the constituent minerals being the same as in the last case, but the individuals are much smaller, and the microliths of apatite are far more abundant.

Slide No. 292 is a section of the granite in the immediate neighbourhood of one of the micaceous segregations and chiefly consists of quartz with very little triclinic felspar. The large individuals of both mica and hornblende exhibit a twisting of the laminæ as if produced by pressure after their crystallisation. In some cases they seem to have been broken, and the ends appear as if forced into the neighbouring individuals. Little or no apatite is present in this section.

(2.) *Quartz and Felspar Porphyry.*—*Slide No.* 299 is a section of one of the porphyry dykes which have intruded the Moruya granite. The porphyritic minerals

are quartz and felspar, but they are barely macroscopic. They are much corroded and cracked, and in a few instances the hornblende might be said to be porphyritic. The base consists of lath-shaped felspars and quartz with fine hornblende microliths. This rock bears a close resemblance to the typical Moruya granite in its general constitution, only differing in its more minutely crystalline texture.

(3.) *Foreign inclusion in Moruya Granite.—Slide No.* 300 is taken from a foreign fragment included in the Moruya granite. It is micro-crystalline in texture, and consists of felspar, augite, magnetite, hornblende, and quartz, with a little apatite. The rock has undergone considerable decomposition. There are a few porphyritic crystals of felspar present, which polarise with great brilliancy, but the general mass is fine grained. The hornblende crystals are remarkably well defined. The quartz is certainly of secondary origin, and I am rather inclined to think that the hornblende is also. Under these circumstances the rock would either be a dolerite or an andesite, probably the latter. It is certainly an example of a fragment of foreign rock caught up by the granite. In this fact lies its chief interest, and it lends thereby additional proof of the intrusive character of the granite.

(*b*) MOUNT DROMEDARY.—Mount Dromedary is an isolated mountain 2,706 feet in height, about six miles from the coast, rising from the undulating littoral area which flanks the main coastal range and lies between the latter and the sea. Its chief mass consists of an intrusive granite. The slates among which the intrusion has taken place do not now occur higher than the base of the mountain. Its surfaces, particularly near the summit, are very rugged and covered with dense vegetation; in fact, so difficult of access are some of the gullies upon its sides that prospectors have been debarred from thoroughly prospecting them even for alluvial gold. On the eastern flank of the mountain reefs have been and are now to a certain extent being worked. They consist of comparatively thin pyrites quartz veins which contain payable gold in such portions of them where the pyrites has undergone a thorough decomposition. These reefs occur in the centre of the granitic mass, and so far as proved are permanent to a depth of over two hundred feet from the present surface. In their neighbourhood many of the joints in the decomposed granite have been found to be rich enough in secondarily deposited gold to repay the work of tunnelling and washing even where neither reef-quartz nor pyrites were present. It is just possible that the hornblendic granite, although not gold-bearing in the sense that it contains free gold as a primary mineral, may have to a large extent supplied, from the decomposition of its contained hornblende the free gold now found in its decomposed portions and joints. This decomposition would never by itself produce payable gold in the general mass of the granite, nor in the alluvial deposits formed by its superficial disintegration, unless free gold was present originally in the rock; but as previously stated, when

it occurs in the neighbourhood of gold-bearing pyrites veins as it does near the top of the mountain it must materially assist in increasing the quantity of free gold resulting from the decomposition of the pyrites in the veins. As a rule the decomposed portion holds enormous quantities of water, whose presence makes it rather difficult to work the reefs in any other way than by tunnelling.

(1.) *Hornblendic Granites* (*Macroscopic Characters*).—Locally the granite varies much in texture and colour. On the mountain itself it is light grey, generally fine grained, with a few porphyritically developed crystals present. On the eastern flank of the Little Dromedary it is more of a flesh colour, containing large porphyritic crystals of felspar. Usually the hornblende and mica are not much in evidence, but occasionally they are abundant. It also contains micaceous and hornblendic segregations and inclusions of foreign rocks, but these do not occur so frequently as they do in the Moruya granite.

Microscopic Characters.—*Slides* 237*a–b* are from the top of Mount Dromedary. The more finely crystalline portions consist of triclinic felspar, quartz, hornblende, and mica, with occasional crystals of a yellow, translucent, isotropic mineral, which is probably garnet. The felspars are usually full of inclusions, are well crystallised, and exhibit well-defined zonal growth lines. In some instances there is a distinctly cross-hatched structure which seems to indicate the presence of microcline. The hornblende, or its product of decomposition (epidote), is often intercrystallised with and appears included in the sections of felspar (Slide No. 237 *a–b*). The included dusty material is frequently arranged along the zonal growth line and sometimes penetrates the crystals from their edges at right angles to their longer axes. Minute crystals of apatite are often seen as inclusions, together with microliths of hornblende. Iron pyrites occurs plentifully, while garnet occurs rarely, usually as an intergrowth with the hornblende and generally surrounded by a dense black border. The latter mineral is as a rule much broken up into minute flakes, or small plates in which the individual crystals are discernable. It seems to have been one of the most easily decomposed minerals, its place being now taken by epidote.

Slide No. 240, from a cutting on the main road, north of Tilba Tilba Township, is similar in structure to the rock described above from the top of the mountain, with the exception that the porphyritic felspars are more largely developed and the hornblendes more decomposed.

Slide No. 240 is from Conditional Purchase 328, north-east of the Little Dromedary. The felspars in this rock are flesh coloured and largely porphyritic. The hornblendes are much decomposed, and all the minerals are more or less saturated with ferruginous material.

(2.) *Augite Granite.*—Between the porphyritic flesh coloured granite on the eastern flank of the Little Dromedary and the granitic junction with the slates at Little Lake, near the coast, a narrow belt of augite granite occurs. Its junction with or relations to the flesh coloured granite were not observed. It is a dark coloured rock with grey felspars and occasionally large porphyritic augites. Its characteristic constituent is augite which is rather a rare occurrence in a plutonic rock, as it is usually found in rocks which have crystallised on or near the surface. It is however here associated with other eruptive rocks which contain augite as an essential mineral, and which will be hereafter described as andesites and propylites. This is as far as I am aware the first occurrence of an augite granite in this colony.

Slide No. 238, from conditional purchase 19, east of Little Dromedary, consists of triclinic and orthoclase felspar, augite, hornblende and quartz with iron ores. The augite is of a light green colour and full of inclusions, and is intimately associated with the hornblende when the latter is present. In many of the sections of augite the peripheries are composed of brown hornblende which shows the characteristic cleavage of the latter and may possibly be a secondary alteration of portion of the augite. The augites have all a distinctly marked thin, black border. The felspars are rather opaque, due to kaolinisation (Pl. IX, Fig. 5.)

Slide No. 295, from the road to Little Lake, east of Little Dromedary is similar in composition to the last. Here many of the hornblendes are quite distinct from the augites, and show inclusions which are remarkably like those occurring in the undecomposed augites, numbers of which contain irregular local patches of hornblende, showing undoubtedly that most if not all the specimens of the latter mineral have resulted from the alteration of augite. Some of the hornblendes still show a kernel of recognisable augite surrounded by pale green hornblende, the alteration having evidently taken place from the periphery of the crystal inwards. Quartz is by no means plentiful in any of the sections of this rock.

Slide No. 298, from road to Little Lake, east of the Little Dromedary, shows a large porphyritic crystal of augite nearly a quarter of an inch in its longest diameter, with a deep green border, and having its inclusions arranged in an indistinctly zonal manner. The hornblende in this section is readily distinguished as it occurs in isolated crystals, and differs in colour from a dull yellow to an opaque green. Scattered through the section occur irregular patches of a light claret coloured mineral which contains included crystals of the other minerals and is indented by them. It is singly refracting and does not occur in a crystalline form but has a very irregular outline, and in some instances occurs in the interior of the felspar and augite crystals. There is I think very little doubt that the mineral is garnet. In most of the augite crystals, the individual zones

polarise in different colours in a concentric manner. This rock somewhat closely resembles, except for the presence of quartz, the rock hereafter described as an augite-felspar-mica rock.

(*c*.) COBARGO GRANITE.—The granite in the neighbourhood of Cobargo extends from about two miles west of the town to Breakfast Creek on the east, a distance of about eight miles.

(1.) *Hornblendic Granite*.—Like the rock of Mount Dromedary it is a hornblendic granite, but presents a somewhat darker appearance, from the greater abundance of mica and hornblende present. It also contains more free quartz.

Slide No. 239, from the road between Cobargo and Bermagui is a section of the typical rock, and consists of triclinic felspars, quartz, hornblende, and mica. So far as I have seen there is no garnet present. The felspars are somewhat opaque, the dark material being arranged in a zonal manner and along the twinning planes. The hornblende varies in colour from pale yellow to light green, and shows the cleavage very distinctly.

(2.) *Quartz and Felspar Porphyries, Slide No.* 274, from the road between Cobargo and Bermagui, is associated with the Cobargo granite, probably in the form of an intrusive dyke. It is a quartz and felspar porphyry. Its base is chiefly composed of minute spherulites embodded among microliths of felspar and quartz. Great numbers of microscopic crystals of a green colour are scattered through the base. They are probably decomposed hornblende. The porphyritic ingredients are quartz, triclinic felspar, and hornblende all much corroded. The last named mineral is decomposed into a green serpentinous looking mineral similar to the green microscopic crystals in the base and containing in one or two instances included lath-shaped crystals of twinned felspar.

(3.) *Dolerite.—Slide No.* 284 is from the main road from Cobargo to Tilba Tilba, near Selection 180. This rock occurs as a dyke mass in the slates immediately to the north of their junction with the Cobargo granite. It is porphyritic by triclinic felspar. It has a doleritic structure and consists of augite, triclinic felspar with magnetite. It would therefore be classed as a dolerite. The felspar crystals indent the augites in a way characteristic of basaltic rocks. Free quartz occurs in the section as porphyritic masses having a somewhat circular outline which is separated from the general crystallised magma by a layer of minute radially situated crystals, which would seem to show that the quartz was of secondary origin and was formed in a cavity as an amygdule. The quartz itself is not in the form of mosaic but polarises as a single quartz plate. It is full of included bubbles, and each plate fills a single cavity.

It is possible that this doleritic dyke mass may have some connection with the small flow of Tertiary lava which occurs overlying the granite and slates between Cobargo and Bermagui, for so far as is known there are no volcanic cones in this district from which the lava could have come.

III.—Andesites.

Associated with the granites of Mount Dromedary and intruded by them, volcanic rocks occur which intrude the slates of the district. They are exposed chiefly on the coast in the neighbourhood of Tilba Tilba Lake, immediately to the east of the mountain, and consists of hornblende and augite-andesites, with their contact varieties, and an augite-felspar-mica rock, which is represented on the western side of the mountain by a small outcrop on Selection No. 375, Parish of Wandellow.

The coast section at Tilba Tilba Lake shows the intrusive character of both the granite and the augite-felspar-mica rock together with a dyke of augite-andesite. Immediately to the south of the outlet of the lake the granite is seen to have intruded the andesites, while about a mile further north the intrusive junction of the augite-felspar-mica rock with the slates is beautifully seen. The cliffs forming the south head of the lake outlet are composed of hornblende and augite-andesites. At one or two points on the beach a floor of granite is exposed which can be traced up to the foot of the cliff, where it forms a decidedly intrusion junction with the andesitic rock, there being a distinct narrow felspathic zone between the two. The porphyritic granite passing up into this zone becomes more of the nature of a fine grained felspathic porphyry, tinged in places with the peculiar greenish colour from the rock which it has intruded. In many positions in this cliff section fine grained felspathic dykes of various thicknesses can be traced passing from the granite into the andesite. They are light coloured porphyries, and in close relation to many of them masses of breccia occur containing fragments of both rocks.

To the north of the lake the augite-felspar-mica rock is exposed on the shore. It is a very heavy black rock containing a good deal of mica. It is wholly crystalline and very coarse grained in texture. Near its junction with the slates, however, it becomes fine grained and compact. The junction is very well marked, and numerous fine grained dykes pass from it into the slates, which at this point dip to the eastward. These are chiefly intruded along the strike of the slates to the north. Light coloured felspathic porphyry dykes, about a chain in width, also intrude the slates in an easterly direction, and cut the dark coloured dykes as well. Inclusions of the augite-felspar-mica rock are of frequent occurrence in the felspathic dykes. There is, I think, little doubt that these felspathic dykes come from the granites of Mount Dromedary, and in their passage through the mass of the augite-felspar-mica rocks, have caught up fragments of the latter. The stratigraphical relations which the andesites bear to the augite-felspar-mica rock have not been worked out, as the country at this point is covered with sand dunes which completely conceal their junction.

Inland to the west of the lake-outlet the rock exposed on the surface is chiefly hornblende-andesite with local decomposed portions, which are propylitic.

(1.) *Hornblende-Andesite.*—This rock, whose minute structure is seen in the typical Slides Nos. 248*a* and 249*a*, from about a mile west of the mouth of Tilba Tilba Lake, consists of a fine aphanitic base composed of minute lath-shaped crystals of triclinic felspar with magnetic and iron pyrites, the iron constituents being frequently aggregated into small irregularly shaped masses. Throughout the base large porphyritic crystals of hornblende, augite, and felspar are distributed. Some portions of the base present, in transmitted light minute irregular clear patches, which under polarised light are completely isotropic. These probably consist of glass, containing a good deal of dusty material which under a high power resolves itself into microliths, seemingly of augite. The arrangement of the constituents of the base shows a distinctly fluidal structure, which is particularly apparent round the ends of the porphyritic minerals, and between two closely contiguous crystals. The base is often streaked with a light green material, (viridite) and along these lines the ferruginous constituent is generally very abundant. Scattered throughout the base many minute green patches occur which may possibly be aggregations of small hornblende crystals, but more probably a green decomposition of micro-porphyritic augite. Fragments of the base occur in indentations in many of the porphyritic minerals. Throughout the base numerous minute fragments of hornblende occur, having always a rounded form with black bordered outlines. These have at first sight all the appearance of being primary basal constituents, but on closer examination I think that they are certainly the last remnants of small porphyritic hornblendes which have barely withstood complete magmatic resorption before the base had undergone final solidification. The same may be said with regard to the occurrence of small augites in the base. In the case of the hornblendes the corrosions have in many instances gone on to such an extent that the position only of the original crystal is marked by an aggregation of magnetite grains. So far as observed there is little or no primary free quartz in the typical specimens of this rock.

In those sections representing the typical rock felspar as a porphyritic constituent is sparingly developed, and never attains the size of the other porphyritic ingredients, although in the altered and decomposed portions of the rock near the junction line of the granite, it is of very common occurrence. The chief porphyritic mineral is hornblende which occurs occasionally in fairly well formed crystals, showing the characteristic cleavage. They are however generally more or less rounded in outline, the result of corrosion. The largest forms which they assume, are elongated, of unequal thickness and irregular outline, attaining a length of one-eighth of an inch. They are always of a yellowish-green colour, having a deep black border evidently consisting of magnetite grains, except in Slide No. 248 where it is comparatively thin.

The border is deepest on those forms which are rounded and have undergone most corrosion, and is less prominent on those still presenting crystalline edges. This would seem to indicate that the black magnetite border was a secondary segregation of the iron constituents of the base, aided by that resulting from the corrosion of the peripheral portions of the hornblendes themselves, during the period between their own crystallisation and the final solidification of the base. They often exhibit a distinctly zonal structure, a well marked cleavage, and are frequently twinned. Inclusions of the base, as well as included crystals of augite (?) occur in them, while two or more crystals, commonly occur in apposition forming aggregates. These often have between them at their line of contact, a deep black band, showing that probably they have not been crystallised together but have been simply carried against one another during the flowage of the base. It would seem probable that the hornblendes are of two generations, the larger number being of primary origin, while a few have resulted from the uralitisation of augite. The corroded forms may possibly be foreign to the rock, but I think that it is more probable that they were simply the first mineral to crystallise out as porphyritic constituents, and that subsequently and during the crystallisation of the base they had undergone peripheral corrosion.

In addition to the porphyritic hornblende and felspar, and almost equally abundant with the former, a clear mineral is porphyritically developed which is usually much cracked and contains a good deal of greenish decomposition material. It presents in section a somewhat roughened surface, resembling that characteristic of olivine, but in all three slides there occur one or two small undecomposed forms having a perfectly crystalline outline and showing undoubtedly the cleavages of augite. In some cases they occur aggregated together into large irregular compound crystals, while sometimes two crystals appear in apposition so as to resemble in section geniculate twins, but this is I think accidental. Like the other porphyritic constituents they have individually undergone, to a considerable extent, magmatic resorption, which has often entirely obliterated their crystalline outlines. They frequently present a black border, which however is never so deep nor so well marked as in the case of the crystals of hornblende. Inclusions of the base and small aggregates of the magnetite occur in them. Some of them show twinning, and they have usually undergone a certain amount of decomposition. The resulting green product is sometimes merely peripheral, but generally passes through the crystal in irregular lines, and in some instances the whole substance of the crystal has been converted into this green material. Frequently there appears to be in those altered forms indications of hornblende cleavage, and it is quite evident in the decomposed specimens of this rock, described below, that the alteration which the augite has undergone has been into uralite. In this way some of the lighter coloured hornblendes, having ill defined borders, have no doubt been derived by alteration from the augites.

This rock is certainly a quartzless hornblende-andeisite, the chief [porphyritic constituents being hornblende and augite, the latter mineral having been frequently converted into uralite. Both minerals have been among the earliest to crystallise out, and have been present in a crystallised form before the final consolidation of the base. There is a little glassy base, but in the typical rock there are a few porphyritic felspars and no primary free quartz. As will be shown further on, in examining sections of this rock near its junction with the intrusive granite, one of the characteristic features of the contact rock is that almost the only porphyritic constituent is felspar, the hornblende and augite being reduced to a minimum. Fig. 1 Pl. IX., represents a portion of Slide No. 249 b.

An ultimate analysis of the hornblende-andesite, made by Mr. J. C. H. Mingaye, Assayer and Analyst to the Department of Mines, is given below, and with it a few analyses of typical hornblende-andesites for comparison:—

	1	2	3	4	5
$Si\,O_2$	52·12	59·75	58·84	55·75	52·68
$Al_2\,O_3$	18·47	17·25	17·09	20·42	12·66
$Fe_2\,O_3$	3·40	7·57	....	6·14	17·34
$Fe\,O$	4·77		10·61	....	....
$Mn\,O$	Trace.	....	....	....	Trace.
$Ca\,O$	8·71	6·00	7·03	8·33	11·45
$Mg\,O$	5·11	1·30	3·90	3·79	0·93
$K_2\,O$	3·29	3·10	0·83	1·90	1·91
$Na_2\,O$	3·07	4·00	2·12	5·74	2·49
$P_2\,O_5$	·25	....	....	....	....
SO_3	Trace.	....	....	....	....
T. O.	Heavy trace.	....	....	....	....
Moisture	·46	1·00	....	....	....
	99·65	99·97	100·42	102·37	99·46

1. Analysis of hornblende-andesite from a mile west of the entrance to Tilba Tilba Lake, South Coast, by J. C. H. Mingaye.
2. Mean analysis of quartzless hornblende-andesite. Von Lasaulx.
3. Analysis of an andesite from Gunung Patna, Java. Prölss, N. Jahrb. f. Min. 1864, p. 432.
4. Analysis of an augite-andesite from the Usiú Pass, Japan, by O. Korschelt. Trans. Asiatic Society of Japan, 1880.
5. Analysis of augite-andesite from N.W. spur, Beinn Hiant, Mull, by W. Tate, Normal School of Mines. Quart. Journ. Geol. Soc., Vol. XLVI, p. 379.

(2.) *Augite-Andesite.*—This is the form which the andesitic rock assumes in the cliff section at the south head of Tilba Tilba Lake, where the granite can be seen intruding it. It differs somewhat in structure from the hornblende-andesite just described, which occurs further inland, and whose junctions with the granite have not been observed. For the latter reason it is unknown whether the last named rock is intrusive or has been a lava.

Slide No. 276 is from the southern end of the bluff forming the south end of the Tilba Tilba Lake. The base consists of triclinic felspar, magnetite, and augite, with some glass and viridite, a decomposition product from the augite or hornblende. The felspars are lath-shaped and somewhat opaque, and larger than they are in the hornblende-andesites. The chief porphyritic constituent is clear augite, having distinctly crystalline outlines and being traversed with several irregular cracks, which are filled with a yellowish green decomposition material. There are a few small porphyritic hornblendes, the major portion of which have been converted into fibrous radial epidote surrounded by a border of magnetite grains. The augites show in some cases zonal growth lines, and are often aggregated together, the spaces between the crystals being occupied by small irregular patches of the base. No porphyritic felspars are present, and the rock generally has the same structural characters as the hornblende-andesites, the only difference being that the porphyritic augites predominate over the hornblendes, and therefore it may be classed as an augite-andesite (Pl. X, Fig. 2.)

Slide No. 282 is from the northern end of the bluff forming the south head of Tilba Tilba Lake. This specimen was taken near the junction of the andesite with the granite, but not at the actual point of contact. Its base is exceedingly fine grained, consisting of minute triclinic felspars and magnetite with a good deal of green decomposition material. Its chief porphyritic constituents are triclinic felspars and clear augites, showing serpentinous decomposition along the cracks. Hornblende, if it is represented at all, is in the form of a green decomposition product. The porphyritic crystals are much corroded, and the base is quite similar to that of the last section and the hornblende-andesite. It is evident that these two forms merely represent local differences of the same rock mass.

IV. Contact Rocks.

Considerable alterations in the general structure of the andesitic rock have taken place towards its junction with the intrusive granite. These results have been produced first by the intrusion of the granite and subsequently by decomposition, and are to be observed as a passage from the typical undecomposed andesitic rock to the purely felspathic pyritous rock which form the actual contact zone between the two. The first noticeable difference is the decomposed condition of the rock, and the development in it of large quantities of zonally built and now kaolinised felspars. The porphyritic augites are almost entirely converted into uralite and the hornblendes into epidote, thus producing propylite. Considerable portions of the contact rocks are brecciated, exhibiting strong evidences of flowage. It usually appears glassy as if the greater portion of the rock in such positions had undergone remelting at the time of the granitic intrusion, and subsequently solidified as a glassy rock containing microliths and porphyritic crystals of felspar and hornblende, many of the latter, however, being

the original black-bordered hornblendes of the andesite which had partially withstood the process of resorption. Enclosed in this glassy matrix occur fragments of all the various altered forms of the andesite. Compared with the typical andesite the iron in the base of the altered varieties has been considerably lessened in amount as a microscopic constituent, but has been developed as microporphyritic iron pyrites. This secondary development of iron pyrites in the rocks near the junction lines is quite a characteristic feature in the coast section to the south of Tilba Tilba Lake.

The contact rocks will be described under the following classes:—Propylitic andesites or propylites, glassy andesitic and propylitic breccias, and felspathic contact rocks.

(1.) *Propylitic Andesites or Propylites.*—The rocks which I have classed as propylites occur associated both with the hornblende-andesite to the west of Tilba Tilba Lake, and with the augite-andesite forming the bluff at the southern head of the lake. It is evidently a contact rock, and has been produced merely by alteration from the andesite by contact and subsequent decomposition.

Slides Nos. 249 and 251 are from a mile west of the mouth of Tilba Tilba Lake. They possess a base similar to that found in the andesites above described, but the iron constituent is not so plentiful, while the felspars, many of which are porphyritic, are developed in greater abundance, and in larger and more defined crystals. They are much clouded, and the whole rock has undergone great decomposition, the base being freely speckled with viridite. In a few instances, much corroded, deep black-bordered crystals of brown-coloured hornblende occur porphyritically, but as a rule they are almost entirely converted into epidote, while commonly the position which they occupied is now represented by a corroded mass of opacite, still exhibiting indistinctly the crystalline outline of hornblende. The other porphyritic constituent has been entirely converted into a green mineral which shows the pleochroism and in many cases the cleavage of hornblende. This is evidently an alteration mineral, and is no doubt uralite resulting from the alteration of augite. This is well seen in Slide No. 260 (Pl. IX, Fig. 2). Some of the uralite still shows portions of the clear unaltered augite. Iron pyrites also occurs as a microporphyritic constituent.

Slides Nos. 252, 252a, 260, 275 are taken from the bluff forming the southern head of Tilba Tilba Lake. Their base contains a great deal more magnetite and iron pyrites than was the case in the two former slides. The originally porphyritic hornblende has been almost entirely converted into epidote which also occurs scattered through the base. The augite has also undergone uralitisation. The chief peculiarity of this rock is, however, the abundance of porphyritic felspar which possess a remarkably zoned structure. Many of the crystals have a completely opaque centre, surrounded by a clear peripheral zone,

while others have alternate opaque and clear concentric zones of unequal thickness. It is common to find them exhibiting fracture, in some instances with but slight displacement, and in others the fractured pieces have drifted apart and are slightly corroded. They are best seen in Slide No. 252, from which the individuals in Fig. 3, Pl. IX, are taken. Occasionally their arrangement would indicate that movements of flowage had taken place in the base after their formation. Some of the larger forms show a central nucleus of magnetite grains. This would, I think, lend support to the supposition that many of them are of secondary origin, that is to say, that they were formed in the rock as a result of the intrusion of the granite. Slide No. 275 is partially brecciated and contains a good deal of glass.

In every particular this rock presents a pathological condition of the typical andesite described above, and therefore would be classed as a propylite, its chief characteristics being the uralitisation of the augite and the secondary development of large quantities of zonally built felspars. On the coast this rock only occurs in the neighbourhood of the junction lines with the granite, and this position would explain its altered condition which has no doubt been chiefly brought about by decomposition by percolating water, together with the effects produced by the intrusion of the granite.

(2) *Glassy Andesitic and Propylitic Breccias.*—In close connection with the lines of contact between the felspathic dykes and the andesite, glassy breccias have been formed. These consist chiefly of a glassy matrix, exhibiting flowage, throughout which are scattered small porphyritic crystals of felspar and hornblende, and enclosing fragments of the different varieties of the andesitic rock. They are represented by Slides Nos. 272, 254, 255, 256, 257, 259, 261, and 262. The majority of the fragments forming the brecciated portions consist of the propylitic variety containing the porphyritic felspars. The bulk of the sections however consist of glass, the microliths and dusty material in which are arranged in lines giving the rock the appearance so common to banded rhyolites. In Slides Nos. 255 and 252 (Fig. 4, Pl. IX), this banding is distinctly visible to the naked eye. In every case porphyritic crystals of triclinic felspar, hornblende, and augite are present in the glassy base. Few of these have distinctly crystalline outlines, and in many cases it is evident from their rounded and irregular form that they have been in process of resorption when the glassy base solidified, and there is little doubt that at least the hornblende and augite are the unmelted remnants of the original andesitic rock which must in these positions have undergone almost complete melting at the time of the intrusion of the felspathic dykes, and solidified rapidly as a glassy breccia along the immediate lines of contact. These breccias occur chiefly in connection with the felspathic dykes, and it is most probable that the intrusion of the latter produced two series of phenomena, the first being the development of porphyritic felspars in the andesite for a considerable distance

from the contact, and the second a remelting of the contact andesite which resulted in the production of the glassy breccia. Such breccias have not been formed at the contact with the mass of the granite which is separated from the andesite by a purely felspathic zone. Slide No. 272 contains a good deal of secondary quartz; most of the iron is in the form of pyrites, and a few grains of porphyritic augite are present. The brecciated character of Slide No. 256 is shown on Fig. 3, Pl. A large portion of Slide No. 261 might be classed as fine grained porphyrite.

(3.) *Felspathic Contact Zone.*—The rock which occurs exposed at the base of the andesite cliffs, forming the southern head of Lake Tilba Tilba, is represented by Slide No. 253. It is a felspathic rock and closely resembles the intrusive granite, and passes, towards its junction with the andesite, into the felspathic contact zone. Under the microscope it is seen to consist of a fine grained felspathic base composed of minute felspars, mica, magnetite, and a green decomposition product. Its chief porphyritic constituents are triclinic felspar, green hornblende, which in a few instances seems to be primary, and in others bears a strong resemblance to the vertical sections of uralitised augite, mica, and iron pyrites, the latter being no doubt secondary. The felspathic constituents are opaque from kaolinisation, and the porphyritic individuals are much cracked, presenting a net work with little or no clear felspar in the meshes. Some fibrous epidote is present, probably resulting from the decomposition of hornblende. The rock would certainly come under the granitic porphyries, having the mica and hornblende as accessory minerals. In its general structure and composition it is undoubtedly connected with the granite, and from it felspathic dykes can be seen passing into the andesite.

The actual contact zone between this rock and the andesite is formed of a fine grained highly felspathic rock. In structural characters it differs somewhat in different positions. Slide No. 264 is a micro-crystalline rock (Pl. X, Fig. 5), consisting chiefly of triclinic felspar with a little hornblende, most of which has been converted into epidote. A good deal of aggregated secondary iron pyrites is present, as well as a small amount of free quartz. There is, however, hardly sufficient of the latter mineral present to class the rock as a granite. The other sections of the contact rock, comprising Slides Nos. 250, 258, and 263, are much finer grained than that last described, in fact, they may be classed as felspar porphyries. They consist of a micro-felsitic base formed chiefly of minute felspars and quartz, in which are developed porphyritic crystals of triclinic felspars, with very rarely a small hornblende crystal, which has usually, however, been converted into epidote. The base is very ferruginous, and there is a good deal of iron pyrites present. The porphyritic felspars are usually much obscured by kaolinisation.

From the general characters of the specimens just described it would seem to me that this felspathic contact zone had been formed from the granitic magma rather than from the andesitic rock, as there is no evidence of any actual admixture of

the two rock masses having taken place to form a contact zone. The line of demarcation between the decomposed or propylitic andesite, and the felspathic contact zone is distinctly marked, although there is, I think, no doubt that the production of the porphyritic-zoned felspars in the propylitic rock has been due to the action of the intruding felspathic rock.

V.—Augite-Felspar-Mica Rock.

This rock is associated with the andesites on the coast at the mouth of Tilba Tilba Lake, and occurs on Portion 375, Parish of Wandellow, on the western side of the mountain where, so far as I know, the andesite is not represented. The rock exposed at the mouth of the lake is augite-andesite, and about a mile further north this rock crops out on the beach, but at no point is the actual junction between the two rocks seen, the only exposures being a few isolated weathered surfaces appearing through the sand between tide marks. The relation which this rock bears to the andesite is therefore at present unknown. That it is an intrusive rock there is no doubt, as exhibited by its contact with the slates, and the dykes which traverse them from that junction. These are well seen about a mile north of the lake outlet. They differ considerably in structure, although they contain the same minerals, and it is just possible that these may be independent intrusions, although in no case have I seen dykes of this rock intruding the andesite. In the Parish of Wandellow, to the west of the mountain, this rock crops out as a small oval patch near the junction between the slates and the granite.

At Tilba Tilba Lake the rock is a very heavy, greenish-black ultrabasic rock. Its chief characteristic microscopically is the great abundance of augite and mica, the felspar being by no means a prominent feature in it. It is granitic in texture, its chief constituents being augite, mica, iron ores, and a little felspar. The most abundant mineral is certainly the augite which rarely occurs in decided crystals. It has a greenish tint, is frequently twinned, contains a large number of inclusions, and is much cracked. Some of the inclusions are arranged in lines no doubt along the cleavages, for many of them cross each other at right angles.

The mica is next in abundance and is of two shades, a dark brown, which rarely shows the striations, and a light coloured mica in which they are always present. Many of these latter forms show a remarkable bending or twisting of the laminæ, which in some of the individual crystals are bent in two directions in their course from one end of the crystal to the other. It usually forms aggregates, and the edges are usually indented by irregular protrusions from the augite individuals.

The felspars are triclinic, and the iron ores occur as black opaque specks and aggregations chiefly in the augite and mica and between the other minerals.

Slide No. 285 is from the first outcrop north of the mouth of Tilba Tilba Lake. The chief minerals are augite, mica, and iron ores, principally iron pyrites. The felspar is triclinic and by no means abundant. Scattered through the slide are minute hexagonal sections of a clear mineral sometimes having a nucleus of iron ore and containing large quantities of inclusions having a circular outline.

Slide Nos. 265b and 277 are from Portion 375, near Dignam's Creek, on the west side of Mount Dromedary, and contains a greater abundance of felspar than the preceding, and shows intergrowths of mica and augite, and mica and iron pyrites. Pl. IX, Fig. 6 is a portion of this slide.

Slide No. 306 is from one mile north of Tilba Tilba Lake. It is very fine grained, and the minerals are remarkably fresh and are about equally distributed. The felspars contain large quantities of apatite microliths. Some of the augites exhibit schillerization and in many cases are intercrystallised with the mica.

Slide No. 278 is taken from a specimen procured by one of the Inspectors of Agriculture to this Department, from near Tilba Tilba Lake, the exact position being unknown. It is undoubtedly, however, referable to this rock, but differs from any of my specimens, in the fact that it is distinctly porphyritic by augite. It consists of a fine grained base of triclinic felspar, augite, mica, and iron ores, in which large porphyritic augites have been developed. Their peripheries are altered into a pale green mineral, which is possibly mica, and they are as a rule schillerized towards their centres.

Slide No. 289 is taken from the actual contact between the intrusive rock and the slates about a mile north of the outlet of Tilba Tilba Lake. It is considerably altered and is of a doleritic texture, consisting of triclinic felspar, uralitised augite, mica, and iron ores. The felspars contain apatite, and the skeleton crystals of iron ore have their meshes filled with mica. In most cases, the uralitised augite has undergone further alteration into epidote.

Slide No. 265 (*a*) from Portion 375, near Dignam's Creek, closely resembles the last section. The augites are, however, slightly more porphyritic, and show distinctly a passage into uralite. The felspars are much kaolinised and show zonal structure. It will be noted that here in this rock the uralitisation of the augite occurs in the decomposed portions of the rock.

VI.—Dyke Rocks.

The intrusive character of the Mount Dromedary granite and of the volcanic rocks associated with it, is well borne out by the number of dykes which pass from these masses into the rocks which they have intruded. Felspathic dykes intrude both the andesite and the slates, and dykes referable to the andesite and to the augite-felspar-mica rock intrude the slates near their junction with these rock

masses. These intruded dykes are well seen in the sections exposed on the coast from Little Lake to about one mile north of the mouth of Tilba Tilba Lake. They are, however, more abundant in the latter position.

(1.) *Andesitic and Augite-Felspar-Mica Dykes.*—These chiefly occur intruding the slates. Slide No. 280 is from a thin dyke very much decomposed, which has intruded the slates, about half-way between the Little Lake and Tilba Tilba Lake. In its general microscopical characters it somewhat resembles Slide No. 276, which is described above as an augite-andesite. It is, however, much decomposed, although the minerals are still recognisable. Like the section referred to, it is somewhat doleritic in texture, but not so coarsely crystalline, and consists chiefly of kaolinised triclinic felspars, minute hornblendes, and magnetite with irregular shaped micro-porphyritic augites, which show no crystalline form, and present minute clear portions of undecomposed augite, appearing between a mesh-work of dark greenish opaque material, probably a decomposition product. The relative abundance of decomposed hornblende present would rather favour the view, that the dyke is connected with the andesitic rocks.

Slide No. 290 is taken from a dyke intersecting the slates about a mile north of Tilba Tilba Lake, and exhibits portion of an included fragment of foreign rock One end of the section shows a fine grained purely felspathic rock, containing a few isolated decomposed crystals of hornblende, which are full of magnetite grains The other portion consists of a porphyritic rock, the base of which is made up of minute triclinic felspars, with augite, a little glass, and very little iron ore. This base is thickly studded with micro-porphyritic and porphyritic crystals of hornblende, augite, and zonally-built triclinic felspars, with a little mica, which may possibly be secondary. The hornblende and augite are in well formed crystals, each mineral showing its characteristic cleavage, and both being of a pale claret colour. The most abundant porphyritic constituent is in dull green coloured masses which are probably vertical sections of uralitised augite. This portion of the rock, which represents the mass of the dyke, has quite an andesitic character (Pl. X, Fig. 6).

Slide No. 305 is from a dyke cutting the slates in the same locality as the last. Like it, it is holo-crystalline, and possesses a doleritic texture. It consists of triclinic felspar, with apatite, augite, and a little mica which, however is chiefly enclosed in the augite. Apatite is very abundant both in the felspar and augite, the iron ores being similarly distributed. The felspars are slightly opaque, and the augite is of a pale green colour full of inclusions, and has undergone considerable decomposition. In some cases the brown mica seems as if it were primary, and had been intercrystallised with the augite. This dyke rock is certainly allied to, if not identical with, the augite-felspar-mica rock above described.

(2.) *Felspathic Dykes.*—These dykes are chiefly developed in the slate-rocks in the vicinity of their junction with the augite-felspar-mica rock, about a mile north of the Tilba Tilba Lake entrance. Similar dykes also occur traversing the andesite to the south of the lake, and can be seen in the bluff which forms its southern head. They are never of any great width, and in the former locality have intruded the dark-coloured ultra basic dykes, as well as the slates. There is every reason to believe that they are connected with the intrusive granitic mass of Mount Dromedary.

Slide No. 281 is taken from a felspathic dyke at the point where it intersects one of the dark-coloured ultra basic dykes. It is much decomposed, and is porphyritic by triclinic felspar and hornblende, the former of which is quite opaque, while the latter, although full of dark-coloured bands, still show remarkably distinct pleochroism. The general base of the rock is felspathic, but from its decomposed condition the component felspar crystals are barely recognisable. Quartz is by no means frequent, and the whole rock is saturated with ferruginous material. It may be classed as a felspar-hornblende porphyry.

Slide No. 296, from same locality, is almost identical in structure and mineral constitution with the last, but has undergone less decomposition, and contains a good deal of secondary quartz.

Slide No. 297, from the same locality, contains a fair amount of primary quartz in the base. The porphyritic hornblendes are wholly decomposed into epidote. The triclinic felspars are, however, as a rule clear, and show a considerable amount of zoning. This rock might be termed a granite porphyry.

Slide No. 303, from same locality and similar to last, is a granite porphyry.

Slide No. 301 from same locality. This dyke differs entirely from those just described in structure. It has no porphyritic constituents, and consists of microscopic crystals of triclinic felspar with hornblende, which has been altered into epidote and quartz. It might, therefore, be classed as fine-grained hornblende granite.

VII.—Sedimentary Rocks altered by contact.

The effects produced in the sedimentary strata by their contact with the intrusive rocks and their dykes has been considerable. The position in which these results are best seen is about a mile north of the mouth of Tilba Tilba Lake. in the neighbourhood of the actual junction where the dykes are best developed, In all cases there has been induration of the sedimentary strata, accompanied by minute contortion of the lines of original sedimentation, and the development of a schistose structure, made apparent under the microscope by the presence of alternate layers of minute hornblende crystals, which have undoubtedly been

developed in the rocks as a result of the metamorphic action set up by the intrusive rocks and their dykes. The minute contortion is more marked in the case of the slates than of the sandstones, which have simply been altered into hornblende schists.

Slide No. 283, is from the actual contact of the augite-felspar-mica rock with the sedimentary rocks about a mile north of the mouth of Tilba Tilba Lake. It is a sandstone which has been metamorphosed by the developement of hornblende into a hornblende schist. The hornblendes are very minute crystals arranged in wavy layers alternating with angular quartz-layers. There is a good deal of ferruginous material present.

Slide No. 304 is from a few hundred yards further north, and is from the contact between a thin ultrabasic dyke and a bed of sandstone. Here the development of hornblende has not been so great, and the schistose character is not so well marked.

Slide No. 291 is also from the same neighbourhood, and is a slate rock altered by contact with this dyke. Its presents minute contortion of the laminæ, which are broken up and separated from each other, the interspaces being now occupied by mosaic or secondary quartz. It therefore exhibits an irregularly schistose structure.

Slide No. 288 is from the same neighbourhood, and has been altered by contact with a dyke. It has originally been a finely laminated siliceous rock, the plications of the laminae are in one part of the section, so acute at their apices that they present remarkably good examples of the formation on an exceedingly minute scale of reversed faults. Hornblende microliths have been developed in alternating wavy layers so as to form the rock into a hornblende schist.

Slide No. 302 is from same locality. It occurs as an included fragment in an andesitic dyke, and is an argillaceous slate, the only alteration produced being that the laminæ assume a slightly wavy aspect.

Slide No. 286, from same neighbourhood, presents a greenish rock composed of decomposed hornblende microliths with veins of secondary quartz.

Slide No. 279 is from the coast between Little Lake and Tilba Tilba Lake, at the southern junction line between the andesite and the sedimentary rocks. It represents a siliceous rock which has been intruded by fine strings of the andesitic rock. Its general mass consists of angular and subangular grains of quartz embedded in a dark argillaceous matrix. In some portions of the section the angular quartzes are mixed up with the intruding rock, and in others the intrusive strings are well defined and their contact lines with the sedimentary rock distinctly marked. The intruding material is without doubt the andesitic rock, the base consisting of minute crystals of triclinic felspar and magnetite with porphyritic

crystals of decomposed hornblende and felspar. Apparently the only effect produced on the sedimentary rock by the intrusion is the development in the neighbourhood of the contact lines of a great quantity of green material, which is probably decomposed hornblende. Crystallisation of the quartz has not been induced, although isolated grains of quartz have been caught up and surrounded by the matrix of the intruding andesite.

VIII.—General Conclusions.

Conclusions as to intrusive character and age of Granites.

The junction lines of the granitic masses, just described, with the slates, as far as I have had an opportunity of examining them, indicate that they are of an intrusive character as regards the Silurian sedimentary rocks. As a rule their contact lines are sharp and well defined, while in many cases the slates, which in their neighbourhood have undergone considerable induration and tilting, can be seen dipping off the granite. Additional proof of their intrusive character is afforded by the fact that in a few localities the slates in the vicinity of the junction have been intruded by felspathic dykes and veins which intersect them from the granite. Instances of such dyke-like intrusions can be seen in the neighbourhood of Moruya, Cobargo, and also on the coast to the east of Mount Dromedary. It may here be stated that as far as my observations have gone every granitic mass which I have seen in this Colony is intrusive. In no instance have I noted the occurrence of a metamorphic granite. The metamorphism of the slates near their junction with the granite has always been merely such an alteration as would be produced by contact with a heated intrusive rock, and never the gradual passage from an unaltered slate-rock through schistose and gneissic rocks into an undoubted granite. This subject will, however, be systematically dealt with at a subsequent date in a petrological monograph on the acidic rocks of New South Wales, which it is hoped may be shortly undertaken. At the junction of the granitic mass with the slates near Burrowa, in the southern portion of the Colony, there is a typical example of the effects produced by an intrusive granite. Here we have a limited area of slate-rocks in which a schistose gneissic structure has been induced by the intrusive rock, but this has not obliterated the actual line of contact, while in the slate area beyond this reefs and loads have been formed by the contraction of the granitic mass on cooling.

The granites of the southern coast have been intruded subsequent to their crystallisation by felsitic and porphyry dykes, which, however, are never of any great width, and many of them are probably very little younger than the intrusion and crystallisation of the granites themselves. Most of them possibly represent intrusions of the liquid magma, from which the granite was formed, which have come upwards through cracks produced in the solid granite immediately on its crystallisation, by the contraction of the mass on cooling. A few may be, however, of later date.

From the fact that the granites or their dykes are never found to intrude the Devonian conglomerates which cap the Silurian slates and the granite in various parts of the district, it is more than probable that their intrusion took place prior to the deposition of the Devonian rocks, the approximately horizontal position of which tends to support this idea. Their intrusion, therefore, probably dates between the Upper Silurian and the deposition of the Devonian conglomerates, the exact position of which in the Devonian Series has not yet been worked out.

As regards the andesitic rocks, it is impossible to say, at present, because of the non-exhaustive examination which has been made of the district, whether the hornblende-andesite occurring inland from the Tilba Tilba Lake has been a lava or an intrusive rock. There is, however, very little doubt that the augite-andesite forming the southern head of the lake is intrusive, as shown by the occurrence of a dyke of this rock intruding the slates between the Little Lake and Tilba Tilba Lake. Its relations to the augite-felspar-mica rock occurring to the northward have not been made out, as there are no sections of the junction exposed. The latter rock is, however, undoubtedly intrusive, its junction with the slates being distinctly seen, and the dykes which traverse the slates near that junction can be traced back to it. These dykes have subsequently been cut by the felspathic dykes of the granite, showing that the intrusion of the augite-felspar-mica rock was anterior to that of the granite.

The rocks termed propylites or propylitic andesites are quite recognisable as decomposed andesites. They have originally consisted of essentially the same minerals, and have the same structural arrangement, but have undergone great decomposition. The felspars have become largely kaolinised, the amphibole has been replaced by chlorite and epidote, while the pyroxene generally passes into uralite, which has subsequently decomposed into chlorite. The positions in which the propylitic rocks occur would also favour this idea, for they are only present near the junction lines of the felspathic dykes and the granite, positions in which decomposition would most readily take place.

One of the most important facts elicited from a study of the Mount Dromedary rocks is the mode of occurrence of uralite. As will be seen from the above descriptions, it occurs in two rocks which are essentially different rock species. It is present in certain portions of the andesite and also in the augite-felspar-mica rock. In both instances it occurs in those positions in which decomposition has been able to go on to a large extent. In the andesite it occurs in the propylitic portions near the line of contact, where the facilities for decomposition have been very great. In the other rock it also occurs only in the decomposed portions. It would therefore seem to me probable that the chief factor in the alteration of the augite into uralite in these rocks had been ordinary decomposition. There is no doubt that in the neighbourhood of the contact lines the pressure must have been greatly increased at the time of the intrusion of the granite, as

is indeed shown by the production of glassy breccias in these positions. It is doubtless true that the pressure referred to exerted a certain amount of influence on the production of uralite from augite, but I think that the facts exhibited by the occurrence of uralite in these rocks point to the effects of decomposition rather than pressure as having been the chief factor in the alteration.

The local effects of intrusion on various rock masses are well seen in the sections exposed on the coast to the east of Mount Dromedary. To the north of Tilba Tilba Lake we have the metamorphism produced in the sedimentary rocks resulting in their alteration into hornblende schists, while to the south of the lake we see the effects produced by an intrusive plutonic rock on an essentially crystalline eruptive rock. In the latter case the result exhibited in the two rocks in the immediate neighbourhood of the line of contact has been as follows:—The passage of the one rock into the other is by no means a gradual metamorphism, but there seems to be a distinct line at which the metamorphism of either rock ceases. The granite has passed into a granitic porphyry, and the latter into a fine-grained felspathic rock which forms the actual contact zone, the difference in texture being merely due to the differential rate of cooling induced by the contact with the intruded rock. On the andesitic side of this contact line we have the alteration of the andesite into a propylite chiefly by decomposition and the development of felspars in the rock consequent upon the intrusion of the granite. Similar results have been produced by the intrusion of the dykes of these rocks, with the addition of the formation of glassy breccias along the actual lines of contact.

XXII.—Descriptions of four Madreporaria Rugosa—Species of the Genera *Phillipsastræa*, *Heliophyllum*, and *Cyathophyllum*—from the Palæozoic Rocks of N. S. Wales: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plates XI and XII.]

I.—Introduction.

THE genus *Phillipsastræa* has already been recognized in New South Wales. The late Prof. de Koninck* recorded the occurrence of *P. Verneuilii*, Ed. and H., in the supposed Devonian of Cope's Gully, near Hanging Rock, but this species has not yet come under my notice. I believe I am correct in saying that *Heliophyllum* has not hitherto rewarded the efforts of collectors. For the specimens now

* Foss. Pal. Nouv.-Galles du Sud, 1876, Pt. 2, p. 69.

described I am indebted to Mr. Rule, of the Technological Museum, Melbourne, who received them from near Yass. Several species of *Cyathophyllum*, both Silurian and Devonian, have been described, principally from the latter formation, and chiefly by Prof. de Koninck. It, however, yet remains to be satisfactorily proved that the localities ascribed to the Devonian are actually within the boundaries of rocks of that age, a fact of which I am at present not convinced.

Of the *Phillipsastræa*, I owe one to the kindness of the Rev. J. Milne Curran, Mineralogical Lecturer to the Technological Branch of the Department of Education, who obtained it at the Limekilns, seventeen miles north of Bathurst; the other to that of Mr. J. A. Wall.

The *Cyathophyllum* was collected by Mr. John Mitchell, of the Public School, Narellan, at the Cave Flat Caves, Murrumbidgee. On another occasion, when in company with him, I had an opportunity of observing its mode of occurrence at the locality in question and obtaining additional specimens.

For the largest *Phillipsastræa* I propose the name of *P. Currani*, for obvious reasons; for the smaller, that of *P. Walli*; for the *Heliophyllum*, that of *H. yassense*; and for the *Cyathophyllum*, that of *C. Mitchelli*, the object of which will be equally apparent.

II.—*Phillipsastræa Currani*, sp. nov. [Pl. XI, Figs. 1-6.]

Thanks to the researches of Dr. A. Kunth* the confusion which existed in the use of the names *Phillipsastræa* and *Smithia* has now ceased to exist. The Author in question showed the identity of the two, and, amongst other curious points, brought to light the fact that the same species had been used by Edwards and Haime as a type for the two supposed genera. According to the latter authors the corals in question depended for their separation on the presence or absence of a spurious columella, or columellarian tubercle. It would appear that this feature is of too unstable a character to be of much value, and that its presence, therefore, in *Phillipsastræa*, and absence in *Smithia*, cannot be accepted as a point of generic importance. The views of Kunth have been accepted by Dr. Clemens Schlüter,† Prof. F. von Roemer,‡ and Prof. H. A. Nicholson.§

Phillipsastræa Currani forms flat tabular masses of some thickness, but without any tendency, so far as the examples which have come into my hands reveal it, to a superposition of strata, nor have they been sufficiently perfect to betray the presence of an epidermis. The weathered surface of the corallum is flat, or very slightly undulating, the margin of each calice being marked as a well defined monticulose rim, and the central tabulate area projecting above it, as the result of

* Briträge zur Kenntniss fossilen Korallen, No. 5, *Zeitsch. Deutsch. geol. Gesellsch.*, 1870, p. 30.
† Verhandl. natur. Vereines preuss. Rheinl. u. Westf., 1881, XXXVIII, p. 199.
‡ Lethæa geognostica, Thiel 1, Lief. 2, 1883, p. 389.
§ Man. Palæontology, Third Edition, 1889, p. 290.

weathering. The corallites are from eight to ten millimeters broad, the calices on an average about four, whilst the intercalicular areas, between the centres of contiguous corallites, are generally ten millimeters. In a polished horizontal section (Pl. XI, Fig. 2.) the boundary of each corallite can be pretty accurately determined, notwithstanding the absence of walls, by the change in direction, or geniculation, of the septa. The monticulose edge of each calice is always darker than the remainder of the corallum, arising from the number and contiguity to one another, of the transverse dissepiments within the interseptal loculi. This apparently thickened circlet is sometimes known as the "inner mural investment," or "mural circle," but there is no defined wall, as will shortly be seen from the description of a vertical section.

Turning our attention now to a thin horizontal section (Pl. XI, Fig. 3.) prepared for the microscope, we find the septa to be from twenty-eight to thirty-two, equal, strong, and somewhat thickened, wholly confluent, straight, a little curved, or generally slightly geniculate. The equality of the septa in length is a marked feature in this species, there being no separation into long and short, primary or secondary, and all stopping short at the mural circle, and in no way impinging on the central tabulate area. At the immediate periphery of each corallite, and where the confluence of the septa of contiguous individuals takes place, the former are thin, but as the mural circle is approached the septa become thicker, but there is not the slightest trace of the primordial septal plate, the structure of each septum being quite homogenous. Around all the corallites there are certain septa, usually five, stouter than the others, and strongly geniculate, assuming a triradiate appearance, and apparently acting as the main union of contiguous corallites one to the other. Many of the septa indistinctly present small-toothed lateral outgrowths, faintly observable, which correspond to the "carinæ" on the septa of *Heliophyllum*. When highly magnified they are seen to be integral portions of the septa themselves, and project alternately on each side as irregular thorn-like bodies.

The interseptal loculi are closely filled with dissepimental vesicles, the cut edges of which are sometimes convex inwards, sometimes outwards, but they become rather irregularly vesicular towards the imaginary peripheries of the corallites, or at that point where the septa become confluent. The inner mural investment, which, by the way, is no investment at all in the sense of a wall, is formed of closely set dissepiments convex outwards. A much better term for this portion of the economy is that of "mural circle" employed by Edwards and Haime.

The central area is filled with irregularly vesicular tabulæ, the cut edges of which are always visible in a transverse section, although one or two calices have been observed devoid of them, and filled with clear calcite, probably resulting from the fact of the section being taken between two complete tabulæ. There is no columella, or even a columellarian tubercle, no pali, nor is there a distinct fossula that I can distinguish.

In a vertical section (Pl. XI, Fig. 4.) the tabulæ are distinctly visible occupying the central area, either completely extending across from wall to wall, or as before described, incomplete and vesicular. Furthermore, there is a gathering up of some of them, as it were, in the middle line, into a continuous laminæ, which if cut transversely might give rise to the appearance of a spurious columella. The distance apart of the tabulæ is also variable. The absence of any structure approaching that of a wall, either at the imaginary periphery of the corallites, or within its supposed boundaries, is also very apparent, the distinction between the tabulate area and the septal zone being formed by the closely packed zones of vesicles previously described. The intimate, close, and copious nature of these is likewise conspicuous, gradually enlarging, and becoming looser in arrangement and formation as the outer zone of vesicular tissue in the interceptal loculi is approached.

The irregularity described as existing in these dissepimental vesicles in the outer portions of a corallite, when viewed horizontally, is produced by their copious development and arched outline, the line of section cutting them in different positions and at varying angles.

A vertical section also shows the marked triareal division of the corallites, a feature which recalls to our minds the structure of the Cyathophyllidæ.

Phillipsastræa Currani possesses the general characters of the genus sufficiently to render it a typical species, but the more important features of its structure at once set it apart from its fellows. It differs from *P. radiata*, Phill.,* from the Carboniferous Limestone, *P. Hennahi*, Lonsd.,† and *P. Pengellii*, Ed. and H.,‡ of the Devonian, by possessing septa of the one order only, each of the species mentioned being provided with both primary and secondary. The two last-named are also provided with pali. *P. Currani* is distinguished from *P. Bowerbanki*, Ed. and H.,§ and *P. boloniensis*, Blainv. sp.,‖ by the large increase in the number of its septa, the former is also a much smaller species, and altogether different to the Australian form. In *P. Verneuili*, Ed. and H.,¶ the septa are far more numerous than in our species, they are also linear merely in the central area, and tent-shaped outside it. The almost gigantic size of the American species *P. gigas*, D. D. Owen,** and *P. Yandelli*, Röminger,†† renders any further comparison almost superfluous, but in the first-named the septa are very numerous, and unite

* Edwards and Haime, Mon. Brit. Foss. Corals, Pt. III, Carb., 1852, p. 203, t. 37, f. 2, 2a.
† Ibid, Pt. IV, Dev., 1853, p. 240, t. 54, f. 4.
‡ *Loc. cit.*, p. 241, t. 55, f. 1.
§ *Loc. cit.*, p. 241, t. 55, f. 2.
‖ *Cyathophyllum*, *Loc. cit.*, p. 230, t. 52, f. 1, 1a.
¶ Archiv. Mus. Hist. Nat., 1851, V. p. 447, t. 10., f. 5.
** Röminger, Geol. Survey Michigan. Lower Peninsula, 1873-1876, III, Pt. 2, p. 129, t. 37.
†† *Loc. cit.*, p. 130.

on the floor of the calice in a small twisted central boss. In *P. cantabrica*, De Vern.,* and *P. torreanum*, Ed. and H.,† the septa are too limited in number. Lastly, with McCoy's *P.* (*Sarcinula*) *tuberosa*,‡ our species agrees in possessing nearly the same number of septa, but in this Carboniferous form they are "slight and very delicate laminæ."

The similarity in size of the septa appears to be an important feature in our species. Several authors, for instance Edwards and Haime, and Röminger, refer to the septa as always being longer and shorter. The latter author remarks§—"Cycle of the lamellæ composed of alternately longer and shorter ones; the longer lamellæ unite in the centre, and form a pseudo-columellar, nodular protuberance, but do not connect into a continuous vertical axis." The uniform size of the septa, therefore, in this species must be regarded as one of some importance, and a point in which it departs from the otherwise typical features of the genus *Phillipsastræa.*

III.—Phillipsastræa Walli, sp. nov. [Pl. XI, Fig. 7].

I take this opportunity of describing a very peculiar species of the present genus, which I owe to the kindness of Mr. J. A. Wall; it is, however, at once distinguished from the preceding by the decrease in the number of the septa, size of the calices within the "mural circles," and the distance of the corallite centres apart. The rock containing this specimen, judging from its appearance, must have undergone considerable alteration, as the characteristic septa in the intercalicular areas have more or less disappeared, but, strange to say, the mural circles, and the septa in their immediate vicinity, are retained in an excellent state of preservation.

The exact form of the corallum and appearance of the surface are unknown, the specimen having reached my hands only as a fragment fit for sectioning; it is so obviously different from *P. Currani* that I do not hesitate to describe it as distinct.

The calices are small, not more than one and a half millimeters in diameter, distant from one another and separated by considerable intervals of septal surface. The septa are twenty in number, and very constantly so, alternately larger and small, but not differing in thickness. The primary extend inwards to the centre of the calice, as ten very well-marked and prong-like lamellæ, converging to the centre but not meeting absolutely, nor in any way becoming twisted. The secondary septa do not extend beyond the mural circle. The latter is formed by from two to four cycles of dissepiments, each cycle in one plane, and

* Edwards and Haime, Mon. Brit., Foss. Corals, Pt. IV, Dev., 1853, p. 242, t. 56, f. 2 *a–e*.
† Archiv. Mus. Hist. Nat., 1851, V, p 452.
‡ Brit. Pal. Foss., Fas. 1, 1851, p. 110, t. 3 B., f. 8.
§ *Op. cit.*, p. 128.

their convexities directed outwards from the circle. In places on the intercalicular areas the general mass of dissepiments are faintly visible, and they seem to have the convex side pointing inwards, as distinguished from those immediately around the calice. Wherever the septa are visible over this area they are found to be invariably confluent as usual in this genus, so that any question which might have arisen regarding the generic affinity of this coral is set at rest. In some cases the calices are filled with clear calcite, in others with the peculiar grey sclerenchymatous matter composing the general mass of the coral, which, at the particular point in question, may perhaps represent tabulæ, but the absence of a vertical section must leave this point in doubt. The calices are from three to six millimeters apart.

This delicate coral is obviously allied to ***Phillipsastræa Bowerbanki***, Ed. and H.,* and even some small varieties of *P. Hennahi*, Ed. and H.† It is named ***Phillipsastræa Walli***, in compliment to Mr. Wall, the collector, who has been instrumental in supplying me with several interesting corals from the Yass District.

IV.—Heliophyllum yassense, sp. nov. [Pl. XI, Fig. 8; Pl. XII, Figs. 1–3].

Heliophyllum is known to occur in a limited degree in the Middle Devonian rocks of Europe and the Upper Silurian of America, but is plentifully developed in the Devonian rocks of the latter country. I am not in a position at present, I regret, to say whether the present specimens are from the Devonian or Upper Silurian of the Yass District, but in all probability they are from the latter.

The species about to be described as *H. yassense* is peculiar for the great development of its septal system, the extreme tenuity of the septa (primordial septal plate), their zig-zag course, and collection into bundles.

Heliophyllum yassense possesses a compound corallum (Pl.XI, Fig. 8.), the corallites growing in small bunches, and occasionally singly. The colony which has come under my notice measures three inches in diameter and two inches in height, the largest corallite being one and a quarter inches in diameter, but a solitary individual measured two inches. When the outward form is visible the corallites are seen to be elongately turbinate, but little curved, and expanding rapidly upwards. The epitheca is not preserved, and the growth annulations are feeble, wide apart, irregular, and obtusely rounded. The calices are exceedingly shallow, the corallites becoming almost flat-topped.

In a horizontal section (Pl.XII, Fig. 1.) prepared for the microscope the following characters are discernible:—The proper wall appears to be very thin, and is continued inwards along the septa as a very slight thickening of the primordial septal plate. The septa vary from one hundred and forty-five to one hundred and fifty,

* Mon. Brit. Foss. Corals, Pt. IV, Dev. 1853, t. 55, f. 2.

† *Ibid*, t. 54, f. 4*a*.

and are unequally developed, although no determinate subdivision into primary and secondary takes place. They are very fine and hair-like, minutely flexuous or zig-zag, extending almost to the centre of the calice, where they remain untwisted, and tail-off on a very small tabulate area. At about two-thirds the width of the calice from the periphery the septa converge together in bundles of six, but they do not actually unite. Here and there a short septum is met with, but they are much too irregular in position to be considered as "secondary" septa. The carinæ are small and thorn-like, alternate on the sides of each septum. Near the centre of the corallite they cease to occur, except immediately round the edge of the small tabulate centre, where they form a pronounced ring.

As a rule, the more prominent dissepiments filling the interseptal loculi are much bent outwards, geniculate in fact, although a few may be seen here and there convex inwards. Many of the dissepiments are circular or oval when seen in section, a form which can only arise from their perfect condition being that of vesicles, the circular or oval outline representing the cut edges. These are chiefly present in a peripheral zone, followed in an inward direction by the geniculate dissepiments, between which and the tabulate area intervenes the zone devoid of them. The peripheral circlet of vesicles is large, and more or less rhomboidal.

The only evidence of a fossula observable exists in the form of a short tabulate depression on the more convex side of the corallum near the periphery, and is therefore dorsal. Into it two or three indistinct septa are seen intruding themselves.

The presence of stereoplasma to any appreciable extent in this coral has not been observed, the septa being confined almost wholly to the primordial plate; neither is there any in-filling or consolidation in the septal loculi. The central tabulate area is very small, and the tabulæ are incomplete and vesicular.

In a vertical section (Pl. XII, Fig. 3), one of the first points which strikes the observer is the long narrow pipe-like tabulate area, with both complete and vesicular tabulæ. At the peripheries of the corallites the large marginal rhomboidal vesicles are a prominent feature. Passing towards the interior of the corallites the large mass of dissepimental vesicles are conspicuous, convex upwards and inwards. Some, however, are bounded by almost vertical walls, which, I think, explains the form of those more or less circular vesicles to which attention was called when describing the horizontal section.

When a section cuts a corallite at all obliquely, as in some parts of the present one, the carinæ of the septa are very plainly visible, and their lateral position on the latter at once becomes apparent.

In addition to the large and often vesicular tabulæ in the calice, other smaller tabulæ are visible amongst the inner or distal ends of the septa. These are always regular, mostly horizontal, and generally complete, and mark the limit of the central area seen in a horizontal section, which is almost non-vesicular.

From the large number of species of *Heliophyllum* known, *H. yassense* may be compared with the following, to which it bears some resemblance. *Heliophyllum confluens*, Hall,* from the Upper Helderberg rocks of New York State, but the number and structure of the septa separate the two at once. *H. eriense*, Billings,† is similar in the structure of the septa, but the corallum is formed of long straight corallites, and the mode of growth is therefore widely different. This is a coral from the Corniferous Limestone. In its mode of growth our species also resembles *H. proliferum*, Hall‡; in fact, it is in this feature a combination of this species and *H. confluens*. The former must not be confounded with a species of the same name published by Nicholson, and antedating that of Hall. *H. proliferum*, Nich.,§ from the Corniferous Limestone, resembles our species in being compound, or rather composite, but differs completely by its much smaller number of septa, and by having these twisted at the centre, and elevated as a columellarian boss.

V.—Cyathophyllum Mitchelli, sp. nov. [Pl. XI, Figs. 9 & 10; Pl. XII, Fig. 4].

This species is a plentiful fossil in the "Siluro-Devonian" limestone at Cave Flat, junction of the Murrumbidgee and Goodradigbee Rivers, Co. Harden, where it was collected by Mr. Charles Jenkins, L.S., and again by Mr. John Mitchell and the Writer. The specimens so obtained form the basis of the present paper.

The corallum is compound, and forms large spreading sub-tabular masses of considerable extent and thickness. The polygonal, but more generally hexagonal, corallites possess an average diameter of ten millimeters. On a weathered surface the walls stand conspicuously above the general surface of the corallum, whilst the calices are shallow with a slightly projecting spurious columella. The corallites are but indifferently soldered together, for on fracture one exterior of the long prismatic tubes is always exposed to view, bearing sub-angular rugæ and irregular transverse growth wrinkles.

A horizontal microscopic section (Pl. XI, Fig. 10) reveals the fact that the coral, with the limestone, has undergone much change and alteration, and rendered the study of the former somewhat difficult. The walls are slightly flexuous, the primo-

* Pal. N. York. Illustrations Dev. Fossils: Corals, 1876, t. 26, f. 3 and 4.
† Nicholson, Pal. Prov. Ontario, 1874, Pt. 1, p. 281.
‡ Hall, *Loc. cit.*, f. 1, 2, and 5.
§ Pal. Prov. Ontario, 1874, Pt. 1, p. 27.

ridial wall being distinguishable as a dark line, which easily separates into its component elements during the operation of section making. The primordial septa are not visible as similar dark lines, but each septum seems composed of the ordinary sclerenchyma, and there is no thickening by stereoplasma. The septa vary from forty to forty-four in number, and there is hardly any difference perceptible whatever between primary and secondary. They pass from the periphery in a slightly curved direction to the corallite centres, where the distal ends become commingled and partially twisted to form a slightly projecting pseudo-columella. The interseptal loculi are occupied by dissepiments for about one half the diameter of each corallite, and at that point they cease, with the exception of an occasional irregular one. In the outer area in question the dissepiments are regular transverse bars, slightly convex outwards, and arranged in about five regular cycles. Beyond the inner termination of the dissepiments the central part of each corallite appears to be tabulate, with the septa passing over to partially coalesce in the centre. Scattered throughout this central area are some peculiar dark granular bodies, which do not appear to have any definite arrangement.

In a vertical section (Pl. XII, Fig. 4), the bi-areal structure of the corallum is exceedingly well shown. In the outer zone the large dissepimental vesicles are seen between the somewhat distant septa, with their convexities presented inwards and upwards. In the central area the convergance of the septa to commingle at the central point brings them much closer together, and between may be observed the delicate tabulæ. We also have an explanation of the scattered granular bodies seen in a horizontal section, for they seem to be broken off spines, here and there still projecting from the sides of the septa, and reminding us, so far as their position goes, of the septal spines in two perforate corals, *Alveolites Labechii*, Ed. and H., of the Wenlock Limestone, and *A. Battersbii*, Ed. and H., from the Middle Devonian.

I have experienced some difficulty in discriminating amongst the large number of species of *Cyathophyllum* so far published, but morphologically speaking, *C. Mitchelli* appears to approach nearest to *Cyathophyllum rugosum*, Hall,* and *C. Palmeri*, Meek.† The general habit of the former strongly reminds us of that of the present species, but the calices are too large, although the septa varying from thirty-five to forty-five substantially agree with those of *C. Mitchelli*. As regards the second species above mentioned, *C. Palmeri*, the corallites are again too large, and the septa, from twenty-eight to thirty-four in number, are too few. Furthermore, the spurious columella, although formed of untwisted lamellæ is much more distinct than in our species.

* Geol. N. York, 4th District, 1843, p. 159, No. 32, f. 2; Röminger, Geol. Survey Michigan. Lower Peninsula, 1873–1876, III., Pt. 2, p. 106, t. 37 (upper row).

† U.S. Geol. Explor. 40th Parl. (King's), 1877, IV., Pt. 1, p. 33, t. 2, f. 2.

In *C. rugosum*, Hall, Röminger describes the edges of the septa as crenulated, "the side parts traversed by arched carinæ, which in some specimens are almost obsolete, in others very distinct." This would ally *C. rugosum* with *Heliophyllum*, and still further separate it from *C. Mitchelli*, for although the septal spines of the latter are very peculiar, they can hardly be looked upon as homologous with the carinæ in *Heliophyllum;* and they are confined to the inner ends of the septa, within the central area.

It affords me much pleasure to associate with this coral the name of Mr. John Mitchell, of the Public School, Narellan, with whom I carried-out some expolrations at the Cave Flat Caves.

XXIII.—The Cave-Shelters near Wollombi, in the Hunter River District: by P. T. Hammond, Field-Assistant.

[Plates XIII–XV.]

The following Notes were made during an inspection of the Cave-Shelters in the vicinity of the town of Wollombi, some of which give evidence of having been, at one time, tenanted by the Aborigines.

Two of the caves are situated in a small gully about two miles on the northern side of Wollombi Township, within five chains of the Cessnock to Wollombi Road; their position will be seen more clearly by referring to Pl. XIII.

They are within a chain of one another, both facing N.N.W., and are large caverns weathered out of the hard rock, which appears to be one of the finer conglomerates of the East Maitland Coal Measures, which are here dipping in an easterly direction. Smaller caves are frequent in these beds in many places in the neighbourhood, similar to others that I have observed in the Upper Marine beds at Ællalong, and near Richmond Vale and Cessnock, there weathered out of sandstone and the finer conglomerates, and which in some places near Cessnock contain stalactites and stalagmites of considerable magnitude, owing their origin to the infiltration through the marine beds of water holding carbonate of lime in solution derived probably from the marine shells, which occur in numbers in some of the surrounding strata.

The larger cave (Pl. XIV., Figs, 1 and 2), is entered by a small opening almost concealed by grass and creepers, being only about eighteen inches above the ground, so that it is necessary to go on hands and knees in order to enter, and the interior being so dark as to necessitate the use of candles. It is a large somewhat elliptical chamber, the walls of which are rough and pebbly, and covered to a height of six feet with names written by visitors, but showing no aboriginal drawings or carvings, and the mound of earth which forms a crescent along the whole length of the cave had evidently been washed in by floods, and contained neither shells, flints, nor implements of any description, and indeed in time of flood would not be habitable. The cave is fifty-seven feet long by twenty-four feet broad and fourteen feet high in the highest part, having a dome-shaped roof, the entrance is along one side and is partly filled with pebbles and small water-worn blocks of stone, and rubbish carried in by the water. It is hollowed out of a bed of rock which has a perpendicular face twenty-nine feet high.

The other cave is of similar dimensions, with the exception of its height, which is only ten feet, and is roughly elliptical in shape, having a very rugged floor and wall, and, like the one previously described, has nothing to commend it but its size, which is uncommon in a sandstone or conglomerate formation, but about two chains further to the south and facing the west is a cave sixty feet long, showing many aboriginals markings, and having an ash mound at the entrance, from which I obtained a good many examples of *UnioAngasi*, now living in the creeks in the vicinity, and a few sharp-edged flints, which had evidently been carried there and used as skinning knives by the blacks. Some of these, as also the shells, were found at a depth of from two to three feet from the surface of the cave floor, the flints being of quite a different character from any of the rocks I observed in the locality.

The markings on the walls of this cave consisted of representations of twelve hands and portions of hands outlined with, and surrounded by white on the dark background of the rock, and possibly produced by holding the hand flat against the surface of the rock and splashing round it with a white-wash made perhaps from some description of pipeclay or hearth-ash. One of the markings had been cut out and taken away, and another had been worked round probably with the same intention.

Two of the hand markings are large, evidently produced from the hands of male adults, whilst the rest are of much more delicate proportions, some perhaps produced from those of children, or women.

All the hand markings in this cave, with one exception, are those of left hands, the one exception I think being sufficient to prove that it was rather on account of the convenience with which the left hand could be splashed round (the right

holding the implement used), than for any purpose of symbolism that the preponderance of left hands is due. It is noticeable also that they occur frequently in groups of three, but this too may be only on account of convenience. This shelter is sixty feet long, the markings and ash mound being principally in the right-hand side of the cave.

Another cave, (Pl. XIV, Fig, 3), the last visited, occurs on the outskirts of the township of Wollombi, at the spot indicated on Pl. XIII, a few chains from the bank of Narrone Creek, and is a horizontally projecting ledge of rock, shelving slightly inwards, the entrance to which faces N.N.E., the height being about seven feet four inches, and running back for fifteen feet, the length being sixty-six feet. This shelter is profusely decorated on both walls and roof, where it could be reached by hands, and has also a drawing done in white, possibly intended to represent the sun, and consists of thirty-eight diverging rays, the whole forming a circular object two feet across. Here are represented both adult and children's feet low down on the wall, splashed in the same manner as the hands, and showing that at the time the cave was inhabited the level of the floor was probably the same as at present, the feet have the characteristic breadth of those of the native race. Right hands are not infrequent in this cave, though here also the left preponderate, and many are evidently those of very small children. Besides these, representations of three boomerangs and a native tomahawk are faintly discernible on the roof, the latter with a hand placed across the end of the handle with fingers outstretched. All the representations in this shelter have been splashed in the usual way with the exception of that of the sun already described, and of a native shield, both of which are sketched in outline. The hands in nearly all cases point upwards or sideways, but there are two exceptions to this rule also. In the case of this shelter, as well as in that of the one previously described, some markings have been cut out and removed by visitors. Most of the chips of flint were obtained from this shelter last described.

I heard of many other caves said to be ornamented with drawings of native animals and birds, at a distance of from nineteen to thirty miles from Wollombi, but I could not obtain information as to exact localities.

The designs on the walls are in a few cases very plain, but in general they are rather faint.

XXIV.—Idiographic Rock-Carvings of the Aborigines at Flat Rocks, near Manly: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate XVI.]

I.—Introduction.

I AM indebted to Mr. J. J. Fletcher, M.A., &c., Director of the Linnean Society of New South Wales, for pointing out some further fine and well-preserved examples of Idiographic Rock-carvings on an eminence about two and a half miles north-west of Manly, known as Flat Rocks. This group is of interest from the presence of fish of large size, and the outline of an animal not unlike a flying squirrel, and not previously noticed in any series. The Flat Rocks carvings were at one time more numerous than now, but lapse of time has rendered many quite indistinct. The following notes and accompanying sketches were made by Prof. T. W. E. David, B.A., Mr. George H. Barrow, and the Writer.

II.—Locality.

The carvings are situated on some rounded surfaces and an inclined plane of Hawkesbury Sandstone, on Portion 1499, Parish of Manly Cove, overlooking Curl Curl Creek, and locally known as the Flat Rocks. The height of the locality is two hundred and seventy-two feet above Curl Curl Lagoon. The sandstone table is as large, if not of greater extent than that on the range above Bantry Bay, from which the carvings have already been described.* In the present instance, the locality has an easterly aspect, with a commanding view of the Pacific Ocean, the low ground around Manly, and portions of the Port Jackson Heads. Here and there over the table the surface has been weatherworn into shallow pond-like depressions, and it is in some of these that the most interesting etchings have been made.

III.—Description of the Carvings.

The method of execution is quite similar to those above Bantry Bay and elsewhere,—a series of preliminary indentations, rendered confluent by subsequent blows, and so producing a grooved outline.

On descending from the higher ground, just off the road-line, the first carving met with is the large fish, Pl. XVI, Fig. 1, twenty-four feet long, which is indented partly on the flat sandstone table, and partly on a rounded, inclined surface, with an easterly aspect. There is a large dorsal, and a small pectoral fin, two large eyes,

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* Rec. Geol. Survey N.S. Wales, 1890, II., Pt. I, p. 26.

a rather restricted tail with ill-defined flukes, a transversely oblique band placed just behind the dorsal fin, and two incomprehensible horseshoe-shaped bodies somewhat in advance of it. On the outer margins of the eyes are four slits. The transverse measurement of this fish from tip to tip of the fins is eighteen feet. It will be observed that by placing both the eyes on one side of the head, this fish is rendered lopsided, and on this account becomes a strange mixture of symmetry and asymmetry. The slits can be intended for nothing else but the gill apertures.

The subject of Fig. 2 is also a fish. It lies at the head of, or at right angles to, Fig. 1, and has a decided north-east aspect. Here the native artist has followed out the same idea in rendering it lopsided. He also delineated a dorsal and pectoral fin, and seems to have had an idea of a ventral one also. The tail is large and well-defined. From end to end the present figure measures thirty-one feet nine inches, and the diagonal measurement from fin-tip to fin-tip is nearly twenty-three feet. In this instance the pectoral fin is the longest and most important.

Sub-parallel to Fig. 2, and more or less below Fig. 1, is the remarkable fish represented by Fig. 3, sixteen feet nine inches in length, with a greatest transverse diameter of somewhat over thirteen feet. Three fins are represented, one triangular, which may be looked upon as dorsal, and two contiguous, which on the previous supposition can only be regarded as pectoral. This figure has, within its outline, that of a man. This will be referred to later on.

The remaining objects in contiguity to the larger are in one of the depressions of the sandstone before mentioned, consisting of two shields and two kangaroos. Of the former, Fig. 4 is after the type of one of the Bantry Bay carvings;* neither, however, have any obliquity in outline. Fig. 5, in its expanded apices, differs from any, of which I have yet seen a representation, but it looks as if intended to represent the ends of the shield gathered together and tied. One shield is three feet six inches in length, the other four feet three inches approximately. The larger of the kangaroos (Pl. XVI, Fig. 6), seven feet in height, is as correspondingly rude as the smaller (Pl. XVI, Fig. 7) is well executed The latter is about three feet in length. Near the larger of the kangaroos is the outline of a man, bearing the usual evidences of aboriginal workmanship, such as the peculiarly angular elbow and knee-caps, and outstretched arms.

We now come to the objects, nine in number, represented in the largest of the surface depressions, and removed a few feet from the remainder of the carvings. The first to catch the eye is Fig. 9*a*, Pl. XVI, probably intended for a "hammer-headed shark," the figure measuring nearly five feet. Figs. 9*b* and 9*c* recall similar objects recorded from the Bantry Bay carvings,† believed by some to represent cat-fish; but I would also suggest that they may perhaps be intended to convey

* Rec. Geol. Survey N. S. Wales, 1890, Pt. 1, t. 2, f. 9.
† Rec. Geol. Survey N. S. Wales, 1890, Pt. 1, t. 2, f. 15.

the idea of gigantic Holothurians, but their affinity is made still more complicated by the attachment of an oval body to the distal end of one of them (Pl. XVI, Fig. 9*e*). The figures vary from three to four feet long. The depression also contains two fish, one (Pl. XVI, Fig. 9*f*) with the head marked off by a diagonal line, and the other (Pl. XVI, Fig. 9*g*) with a wide gape. The object represented by Fig. 9*h* I am not able to throw any light upon; primarily it seems to be one of the peculiar bodies represented by Figs. 9*b* and 9*c*, with four converging lines from end to end. The last figure is very remarkable, and may perhaps be intended for a flying squirrel (Pl. XVI, Fig. 9*i*), but what the object of the oval body attached to one of the legs is, it is impossible to say.

We have, in conclusion, still to consider the figure of the man within the outline of one of the fish (Pl. XVI, Fig. 3). The position is identical with one of those on the Bantry Bay Range,* with the arms outstretched. The rounded meaningless head and angulated elbow and knee joints, strong characteristics of the aboriginal human figure, when depicted in this way, are well displayed. A still ruder figure of a man, within that of a fish, is given by Mr. F. Mann,† as occurring at Berry's Bay, where there are two upward extensions of what are probably meant for the arms, without any defined head at all.

The only instance of depicted features, on what is presumedly an aboriginal idiographic carving, with which I am acquainted, is the male figure "on a rock between Brisbane Water and the Hawkesbury River," illustrated by Mr. F. Mann.‡ In this, a full-face figure, holding in one hand a bundle of spears and in the other a boomerang, the eyes, nose, mouth, and a crop of bushy hair are shown. In analysing its authenticity, however, as the work of an aborigine, the rounded outline of the limbs, the facial characters, and the absence of the elbow and knee angularity, should not be lost sight of.

It is, however, a significant fact that the figures of women, so far as my own observation goes, are never met with in these idiographic carvings. Mr. E. M. Curr § has made the same observations with regard to native drawings, more particularly in connection with some remarkable sketches at the Granite Range, head of the Mitchell River.

IV.—Carvings at Little Sirius Bay.

Whilst on the subject of the male figure above referred to, it may not be out of place to notice two carvings of heads in relief at the head of Little Sirius Bay, Mossman's Bay, Port Jackson, examined by Mr. J. J. Patterson, Mr. W. S. Leigh and the Writer.

* Rec. Geol. Survey N. S. Wales, 1890, II, Pt. 1, t. 2, f. 12.
† Proc. Geogr. Soc. Australasia, N. S. Wales Branch, 1885, Special Vol., 6th Plate, up. r. hand fig.
‡ Proc. Geogr. Soc. Australasia, N. S. Wales Branch, 1885, Special Vol., 4th Plate, l. hand fig.
§ The Australian Race, 1877, II, p. 403.

On the west side of the bay, on the side of a tramway, leading from the quarry above, is a rock shelter, formed by a huge slab of sandstone, resting against the steep hillside, and but a few feet above high-water mark. This spot, according to tradition, was once an important black camping-place. On this slab were said to exist some interesting idiographic carvings, but we were able to find only two rude faces, side by side, cut in relief, about twice life-size, which are very questionably aboriginal.

The relievos are somewhat depressed, generally with squat and broad noses, although the cheeks are prominent, and the eyes apparently closed, whilst one has a deep groove down the centre of the forehead. The expression is anything but pleasing, in fact rather repulsive, and recalls to one's mind more the work of an untutored white than that of one of the Aborigines. They are much ruder even than the head in profile described by Sir George Grey,* on the face of a sandstone rock at the Upper Glenelg River, North-west Australia. This is unquestionably the head of a Caucasian, and I do not for one moment believe that it is the work of an aboriginal artist.

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* Two Expeds. Discovery N.W. and W. Australia, 1837-39, I, 1841, p. 206, plate.

EXPLANATION OF PLATE I.

Tryplasma Lonsdalei, *Eth. fil.*

Fig. 1. A few weathered corallites, showing general proportions, arrangement, and union by stolons. Nat.

Fig. 2. A single corallite in vertical section with septa, tabulæ, and a stolon at the upper left hand. x 3.

Fig. 3. Another vertical section, cut distant from one of the walls, with tabulæ, a stolon, and the septa as delicate points. x 3.

Fig. 4. Portion of a decorticated corallite with the supposed pores near the base between the outer ends of the septa. x 2.

Fig. 5. Cross section of a corallite with septa, tabulate area, and stolon. x 4.

Fig. 6. Similar section of another corallite. x 3.

Diphyphyllum Porteri, *Eth. fil.*

Fig. 7. Transverse view of a corallite naturally weathered, showing the inward projection of the septa, and tabulate area. x 4.

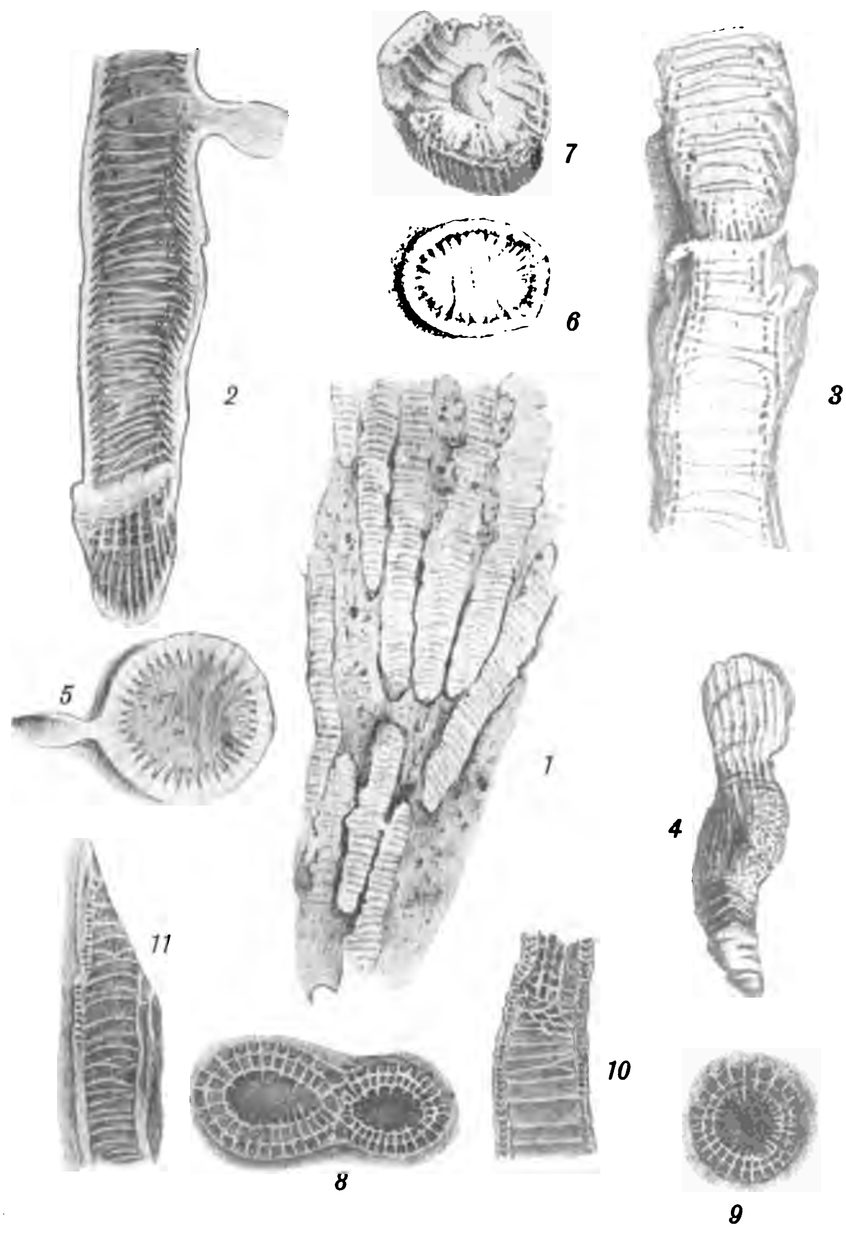
Fig. 8. Cross section of two corallites united, showing septa, dissepiments, and tabulate area. x 3.

Fig. 9. A similar section of another corallite, from which the proper wall has been removed, with the septa projecting outwards. x 3.

Fig. 10. Vertical section of portion of a corallite with the tabulæ at times vesicular, and the inner ends of some of the septa; a single cycle of dissepiments is shown at the margins. (This figure should be reversed bottom upwards.) x 3.

Fig. 11. Another vertical section with the tabulæ bent down at their circumferences. x 3.

The figures were drawn by Mr. G. H. Barrow, of the Australian Museum.



Reproduced by Heliotype.

EXPLANATION OF PLATE II.

Fig. 1. Kangaroo, which on the sandstone table occupies a horizontal posi
5 feet 5 inches by 3 feet 9 inches.

Fig. 2. Kangaroo speared, probably about 5 feet high.

Fig. 3. Ill-defined figure of a man, without the right arm, rather more
5 feet high.

Fig. 4. Porpoise, 5 feet 6 inches by 4 feet.

Fig. 5. Small fish, possibly about 3½ feet long.

Fig. 6. Figure of an animal, possibly intended for a "porcupine" (*Echi*
about 1½ feet in length.

Fig. 7. Probably an eel. It lies parallel with Figs. 5 and 6, but at right a
to Figs. 1 and 3. 14 feet long.

Fig. 8. A shield, hardly bi-laterally symmetrical, with one longitudinal
transverse subdivision, and the apices divided off. Nearly 6½
long by about 4 feet wide.

Fig. 9. Another shield, with a double transverse bar, and one pole divided
5 feet by 2 feet.

Fig. 10. Canoe. 5 feet 6 inches by 1 foot 6 inches.

Fig. 11. (*a*) Male figure with outstretched arms, apparently holding an o
like Fig. 10, and another in the left hand difficult of interpreta
7 feet high.

(*b*) Another male figure opposite Fig. 11*a*, but slightly lower in posit
This seems to represent a man who has just thrown a boomer
5 feet 8 inches high.

Fig. 12. Figure of a man with arms outstretched. About 5 feet ¾ inch in hei

Fig. 13. Ill-defined figure of an animal, perhaps a dog.

Fig. 14. Large fish. This is one of four carvings, three following one anothe
line, and one above the others. Average length, 5 feet; breadth, 2 f

Fig. 15. A nondescript figure, termed by Dr. Carroll a "catfish."

Fig. 16. The largest carving of the group, probably intended to represent
shark. 16 feet 6 inches by 7 feet. At the head and in advance o
is placed the male figure, Fig. 3.

Fig. 17. Perhaps intended for a bream, about 3½ feet long by 2 feet wide.

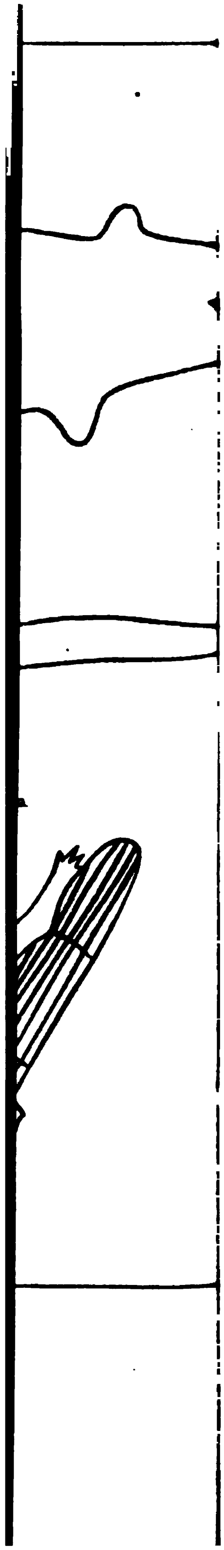
Fig. 18. Boomerang.

Fig. 19. Womerah, or throwing stick, broken short off.

Fig. 20. Large tomahawk, about 1 foot 4 inches in length.

Fig. 21. Possibly a nulla, or waddy.

The figures are drawn by Mr. G. H. Barrow, of the Australian Museu
from measurements made on the ground.



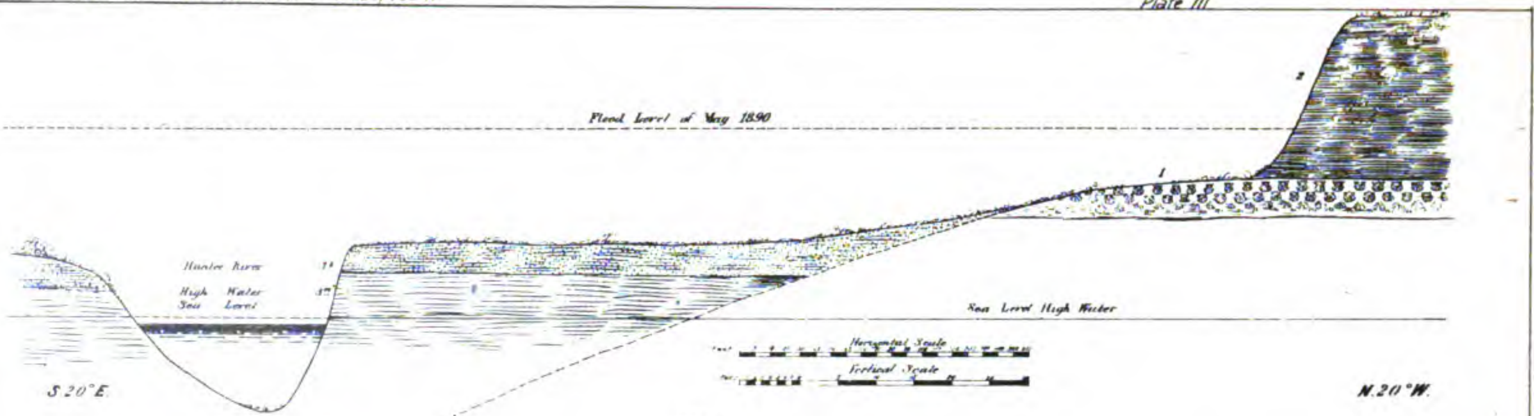


FIG I

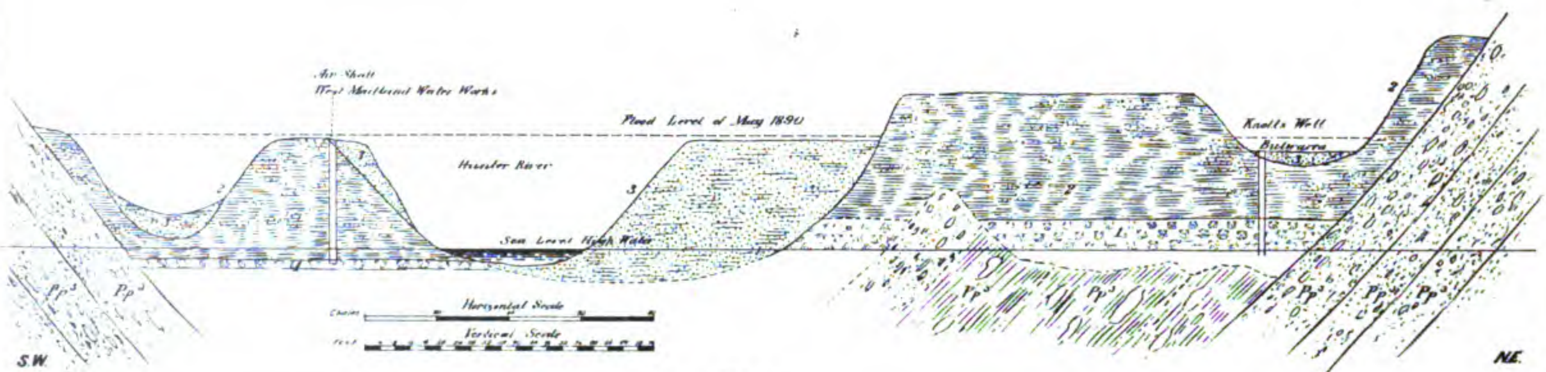


FIG II.

Sig No 306 - 90(c)

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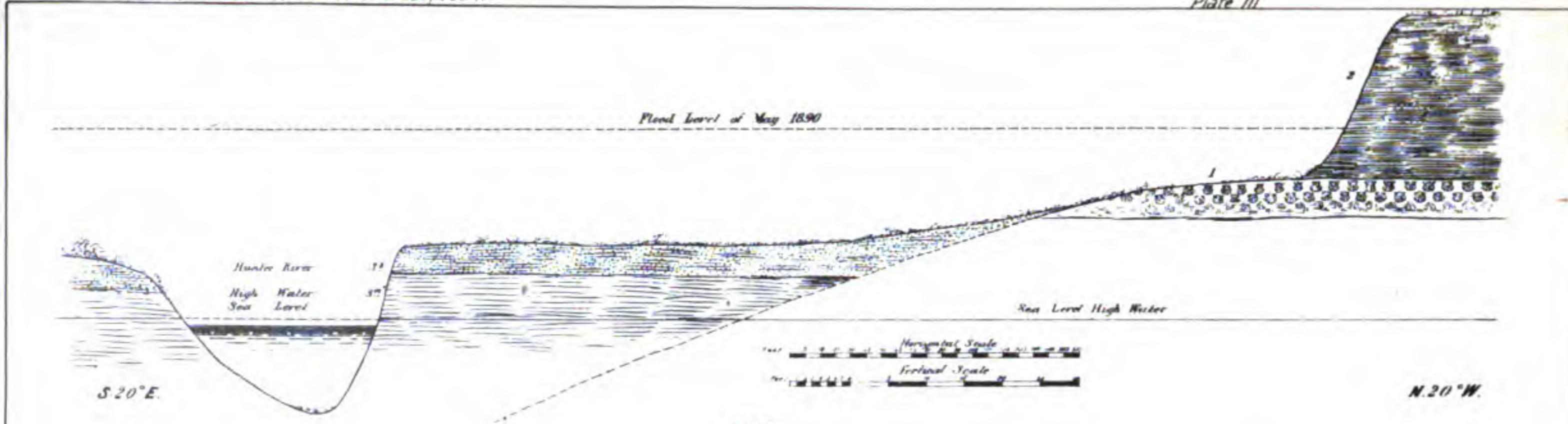


FIG I

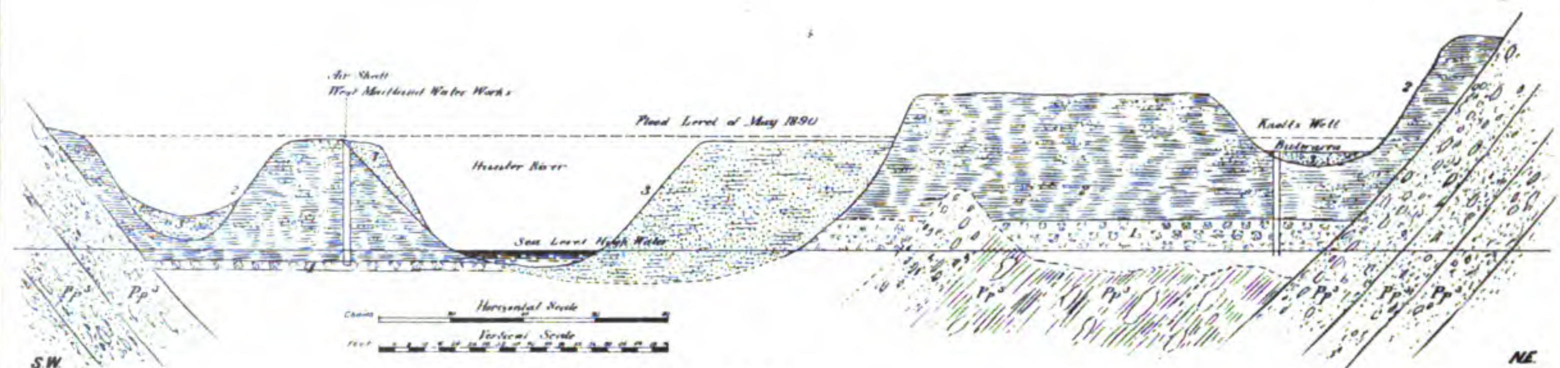


FIG II

Sig No 306 - 90(c)

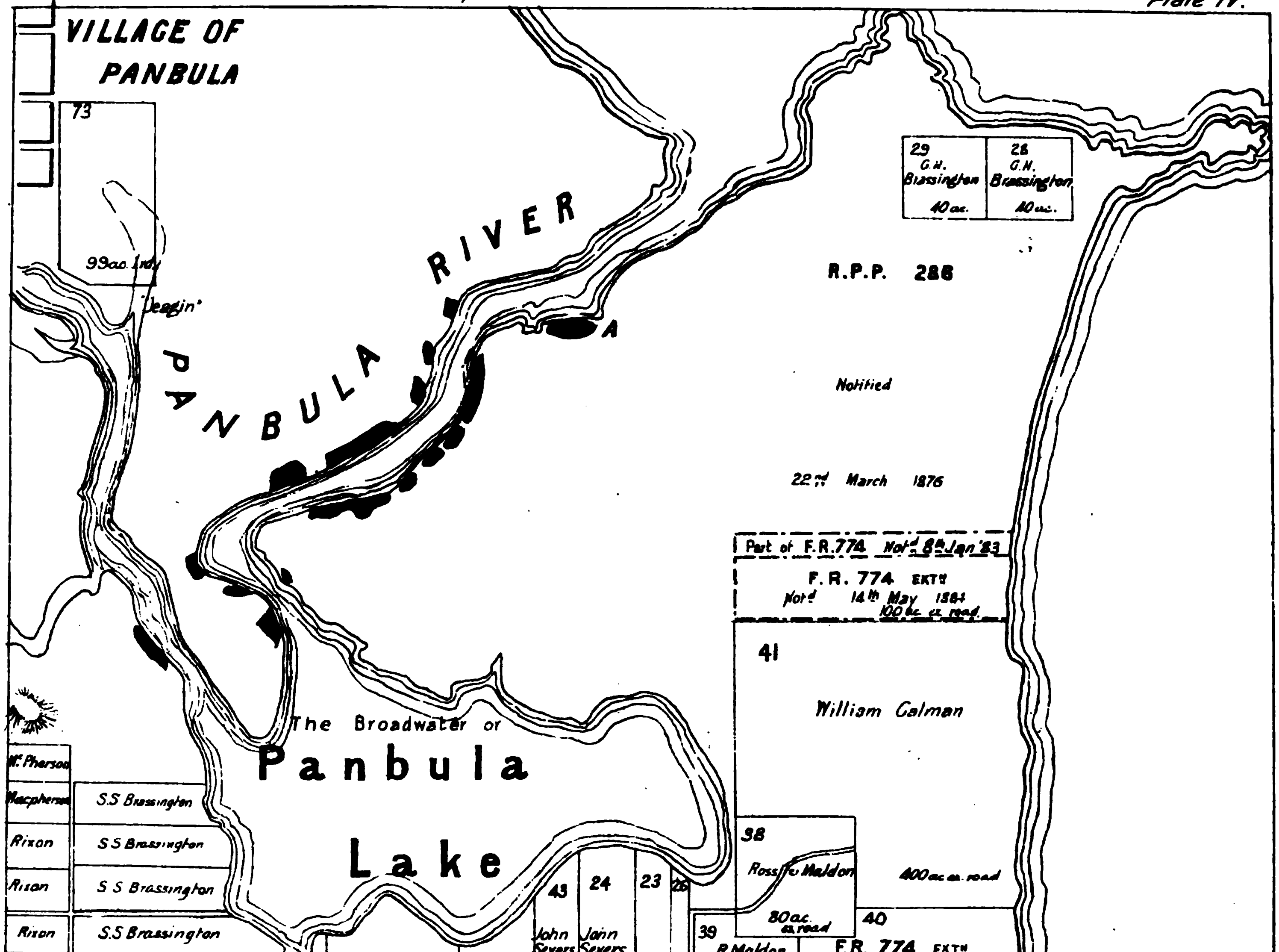
PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE IV.

Plan of the lower part of the Panbula River, showing the positions of the Shell-heaps or " Kitchen-middens " along its banks.

a. = Partially excavated.

= Shell-heaps, or " Kitchen-middens."



Sig. 11a 306–90(d).

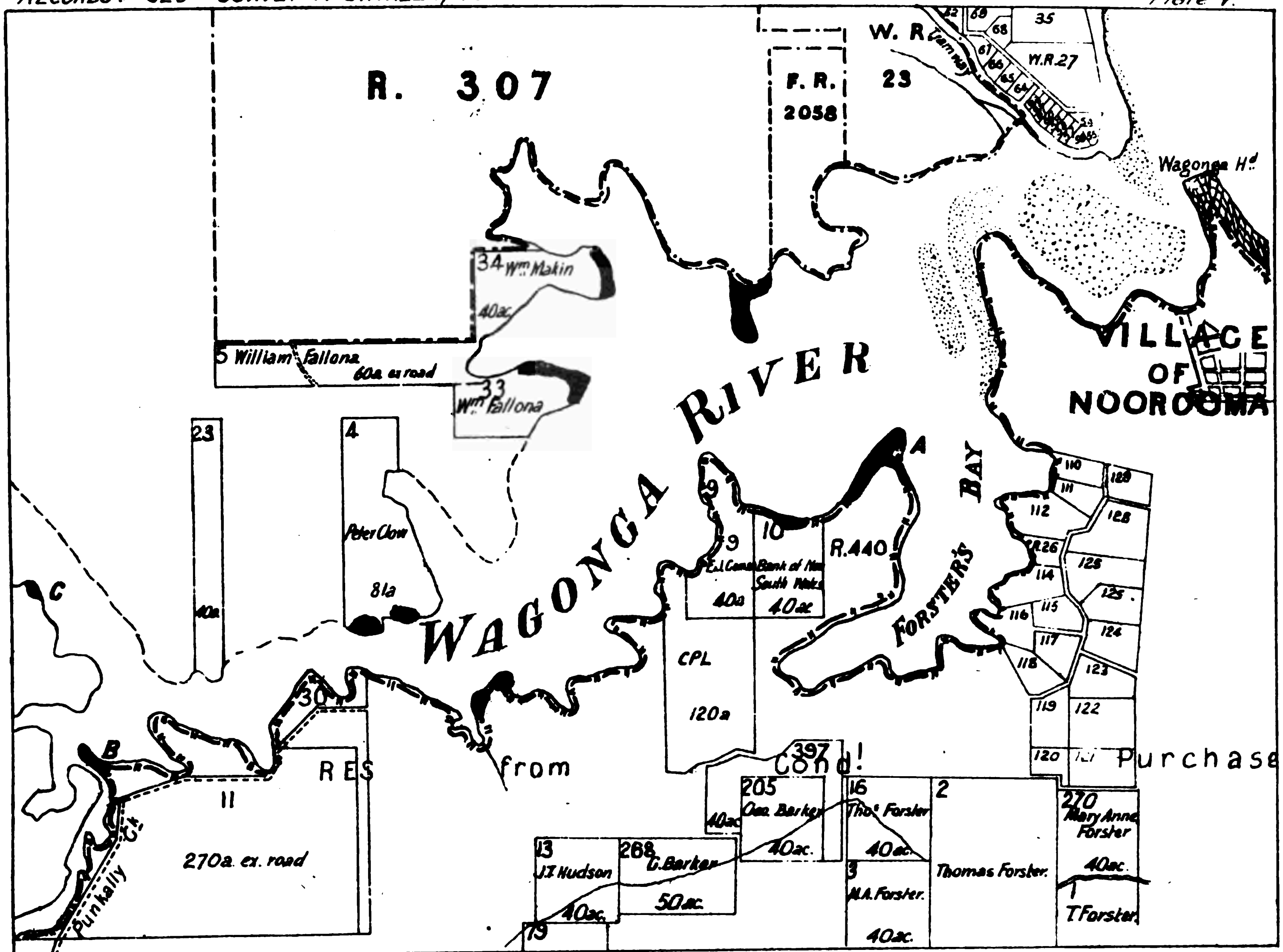
PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

PLATE V.

Plan of the lower part of the Wagonga River, showing the positions of the Shell-heaps, or " Kitchen-middens," along its banks.

a, *b*, *c*. = Excavated.

= Shell-heaps, or " Kitchen-middens."



Sig. IIa 306-90(e).

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

PLATE VI.

Kimberley Spear-heads.

Fig. 1. Elongately-lanceolate, angular on one face, with remains of gum-mounting at base.

Fig. 2. Elongately-lanceolate, glass, with a more decided angularity.

Fig. 3. Elongately-lanceolate, becoming more petaloid at the base.

Fig. 4. Elongately-lanceolate, variegated, the facets large, and highly dentate edges.

Fig. 5. Elongately-lanceolate, angled on both faces, brown chalcedonic-quartz, with strong traces of gum-mounting.

Fig. 6. Foliolate, flattened on both faces.

Fig. 7. Foliolate, flattened on both faces, the facets large, and a well-drawn out apex.

The numbers of the figures correspond to those given in the table on p. 63. The figures are of the natural size.

From drawings by Mr. G. H. Barrow, Australian Museum.

11*a* 306 -90

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PLATE VII.

Fig. 1. Tubes of ***Palæachlya tortuosa***, Eth. fil. Small portions of the tubes permeating the substance of a Monticuliporoid Coral from the Permo-Carboniferous of Queensland.

Fig. 2. Massed tubes of ***Palæoperone endophytica***, Eth. fil., and black spherical bodies from the interior of the corallites of ***Stenopora crinita***, Lonsdale. Permo-Carboniferous of Wollongong, N. S. Wales.

Fig. 3. Tubes of the same, with pin-shaped upper terminations, from the same locality. One of the tubes carries within it five of the spherical bodies serially arranged.

From drawings by Mr. G. H. Barrow, Australian Museum, all highly enlarged.

1

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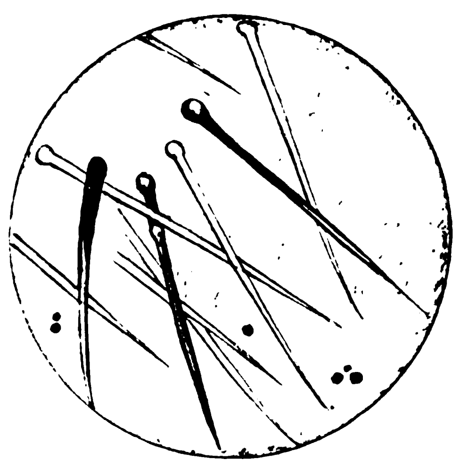

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PLATE VIII.

Sketch plan of the Parish of Noorooma, County of Dampier, showing the distribution of the granite and the associated volcanic rocks of Mount Dromedary.

Drawn by Mr. A. H. Tayler.

11a 369—91

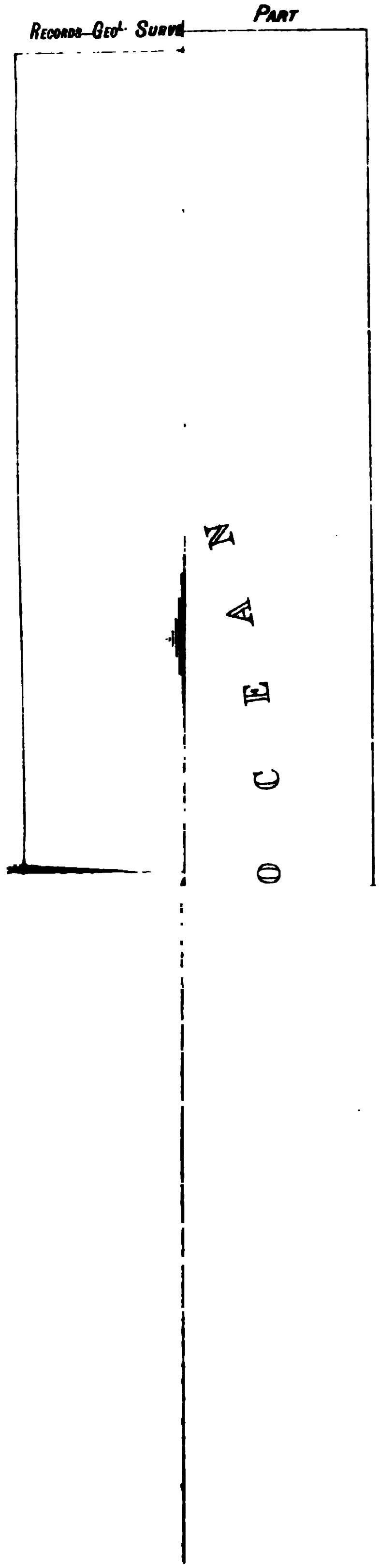
Records—Geol. Surv
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PLATE IX.

Fig. 1. Hornblende-Andesite, from a mile west of Tilba Tilba Lake. (Slide No. 249 (*b*).)

Fig. 2. Propylitic Andesite, from the bluff forming the southern head of Tilba Tilba Lake. (Slide No. 260.) This rock has undergone much decomposition, and the augite has been converted into uralite.

Fig. 3. Individuals of zonally-built felspar, from propylitic andesite. (Slide No 252.) The felspars are probably of secondary origin, many of them having crystallised around a nucleus of iron pyrites.

Fig. 4. Glassy andesitic breccia, from the edge of a felspathic dyke traversing the augite andesite at the southern head of Tilba Tilba Lake. (Slide No. 262.)

Fig. 5. Augite-Granite, from C.P. No. 19, east of Little Dromedary. (Slide No. 238.)

Fig. 6. Augite-felspar-mica rock, from Portion 375, Parish of Wandellow. (Slide No. 265 (*b*).)

Drawn from nature by Mr. P. T. Hammond.

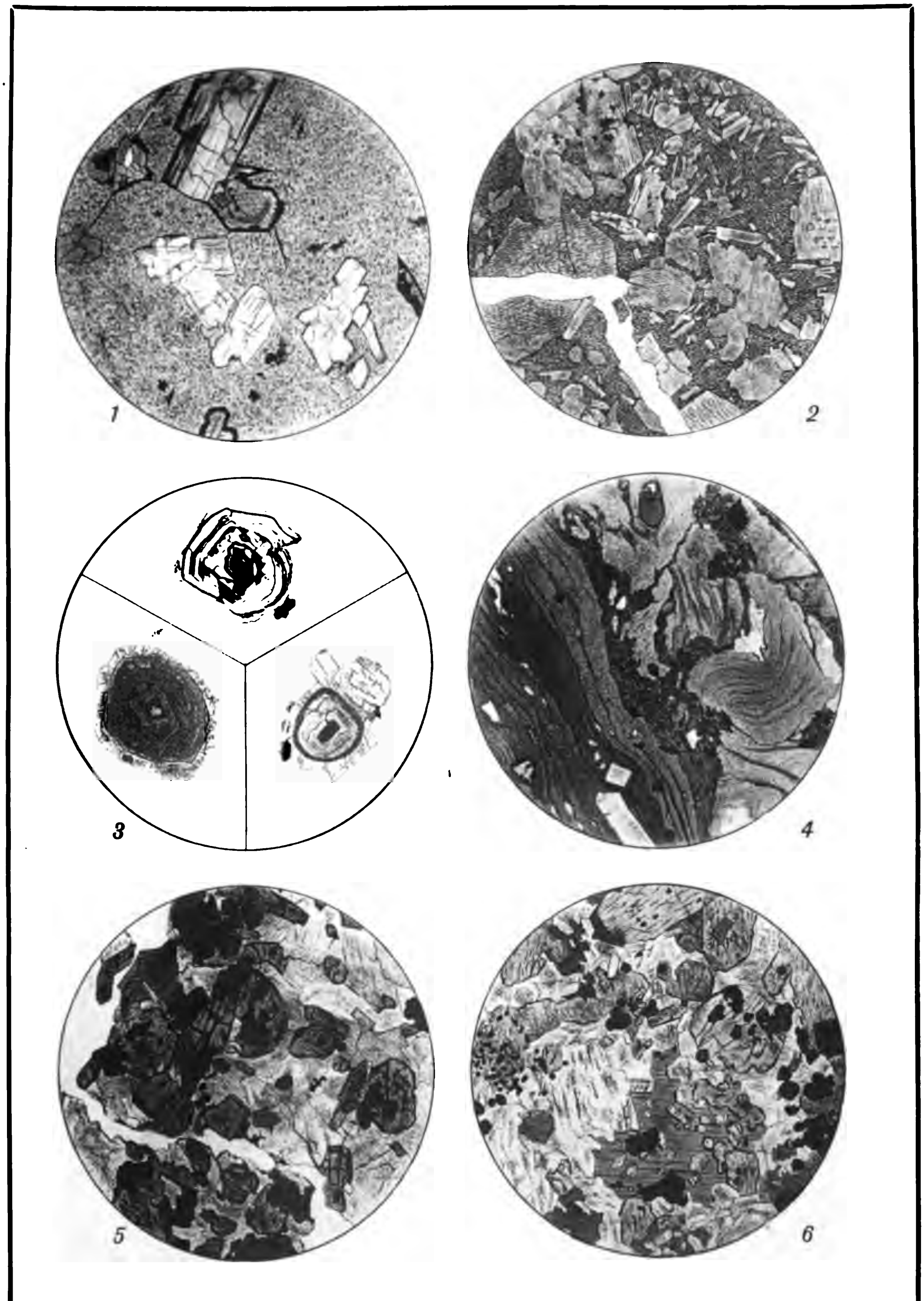

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PLATE X.

Fig. 1. Individuals of triclinic felspar from Moruya granite, showing secondary peripheral growth enclosing minute grains of quartz. (Slide No. 293.)

Fig. 2. Augite-Andesite, from bluff forming southern head of Tilba Tilba Lake (Slide No. 276.)

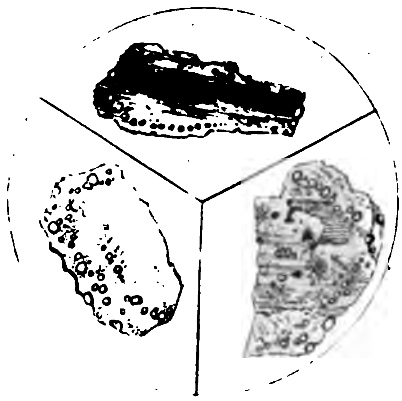
Fig. 3. Showing the brecciated character of the andesitic rock at its junction with the felspathic dykes, at the south head of the Tilba Tilba Lake. (Slide No. 256.)

Fig. 4. Showing the granitic porphyry occurring at the base of the andesitic clin forming the southern head of Lake Tilba Tilba. (Slide No. 253.) This rock passes gradually into the purely felspathic zone of contact with the propylitic portion of the andesite.

Fig. 5. Purely felspathic crystalline rock forming the contact zone between the granitic and andesitic rocks, from the mouth of Tilba Tilba Lake. (Slide No. 264.)

Fig 6. Andesitic dyke rock traversing the slates about a mile north of the mouth of Tilba Tilba Lake. (Slide No. 290.)

Drawn from nature by Mr. G. H. Barrow, Australian Museum.



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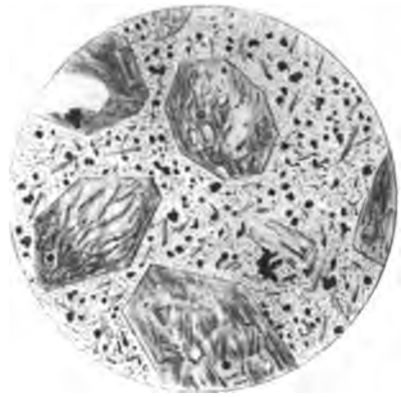

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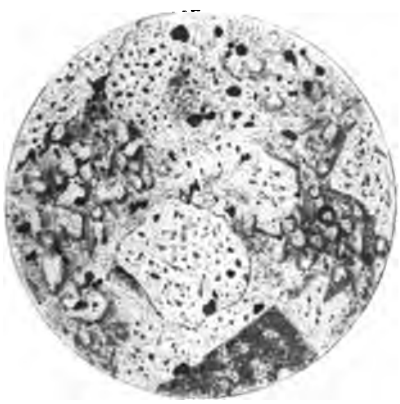

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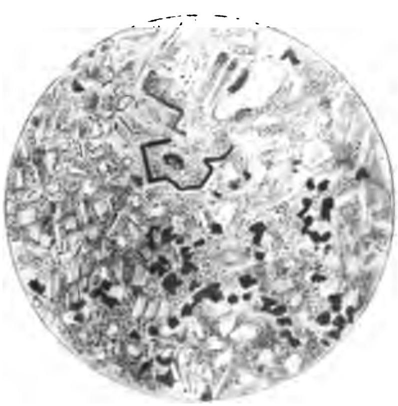

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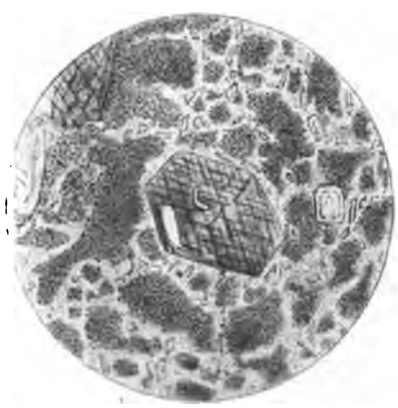

6

PLATE XI.

Phillipsastræa Currani, *Eth. fil.*

Fig. 1. Portion of the surface of a weathered example, showing five corallites.

Fig. 2. Portion of a horizontal polished section, showing the anastomosing, and in places geniculate septa, calices, dissepiments, &c.

Fig. 3. Portion of a microscopic horizontal section, in which the geniculate nature of the septa is shown to greater perfection, the vesicular tabulæ in the centre of the corallites, and the dissepiments filling the interseptal loculi.

Fig. 4. Vertical microscopic section, with the visceral chamber in the centre filled with large incomplete tabulæ, with the closely-packed zones of vesicles on each side, and outside this again the interseptal loculi filled with vesicles.

Fig. 5. Three septa, viewed horizontally in section, to show the manner in which they are broken up

Fig. 6. An interseptal loculum, to show the nature of the infilling vesicles

Phillipsastræa Walli, *Eth. fil.*

Fig. 7. Portion of a horizontal microscopic section, showing four corallites

Heliophyllum yassense, *Eth. fil.*

Fig. 8. A colony, exhibiting the mode of growth and general appearance of the corallites.

Cyathophyllum Mitchelli, *Eth. fil.*

Fig. 9. Three corallites, taken from a weathered horizontal surface.

Fig. 10. A horizontal microscopic section, showing the gathering of the septa towards the centre, without uniting.

Drawn from nature by Mr. G. H Barrow, Australian Museum.

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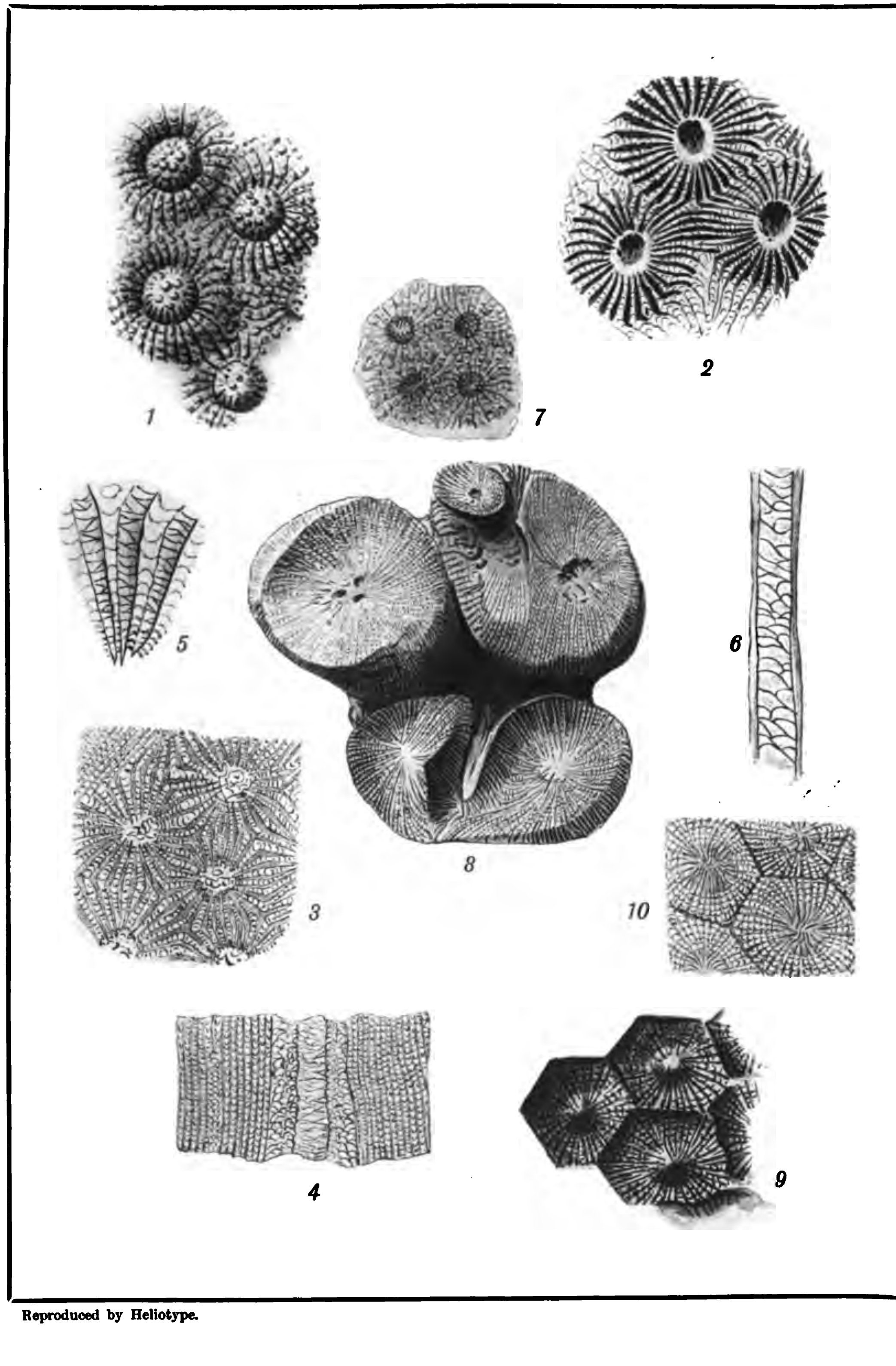

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PLATE XII.

Heliophyllum yassense, *Eth. fil.*

Fig. 1. Microscopic horizontal section, with the innumerable fine, flexuous septa, with a central area unoccupied by dissepiments.

Fig. 2. Four septa enlarged, to show tortuous or zigzag nature, and absence of stereoplasma.

Fig. 3. A partially vertical, partially oblique section, showing the narrow pipe-like nature of the visceral chamber.

Cyathophyllum Mitchelli, *Eth. fil.*

Fig. 4. Vertical section of part of a corallite, with the central zone filled with incomplete tabulæ, and the interseptal loculi with convex superimposed vesicles.

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

3

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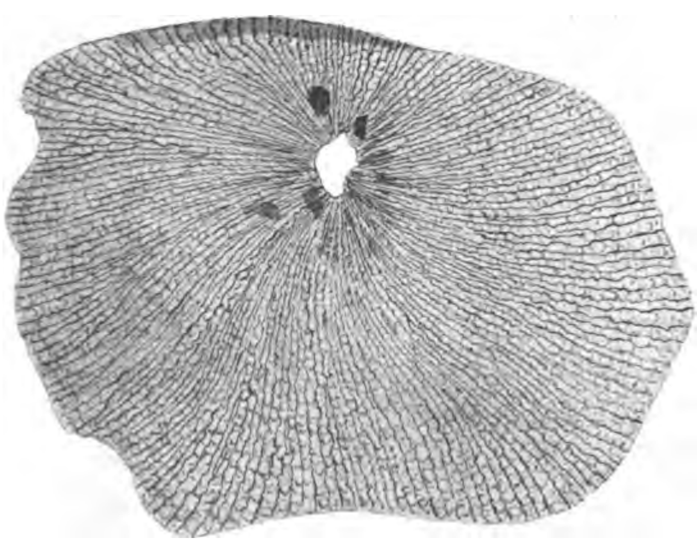

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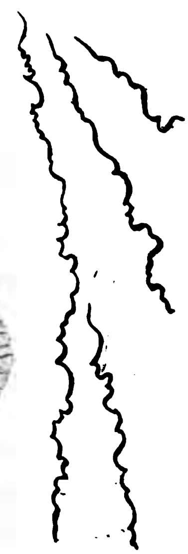

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PLATE XIII.

Plan of the Parish of Corrabare, County of Northumberland, New South Wales, showing the position of the Cave-shelters, near Wollombi.

Drawn by Mr. P. T. Hammond.

11a 369—91

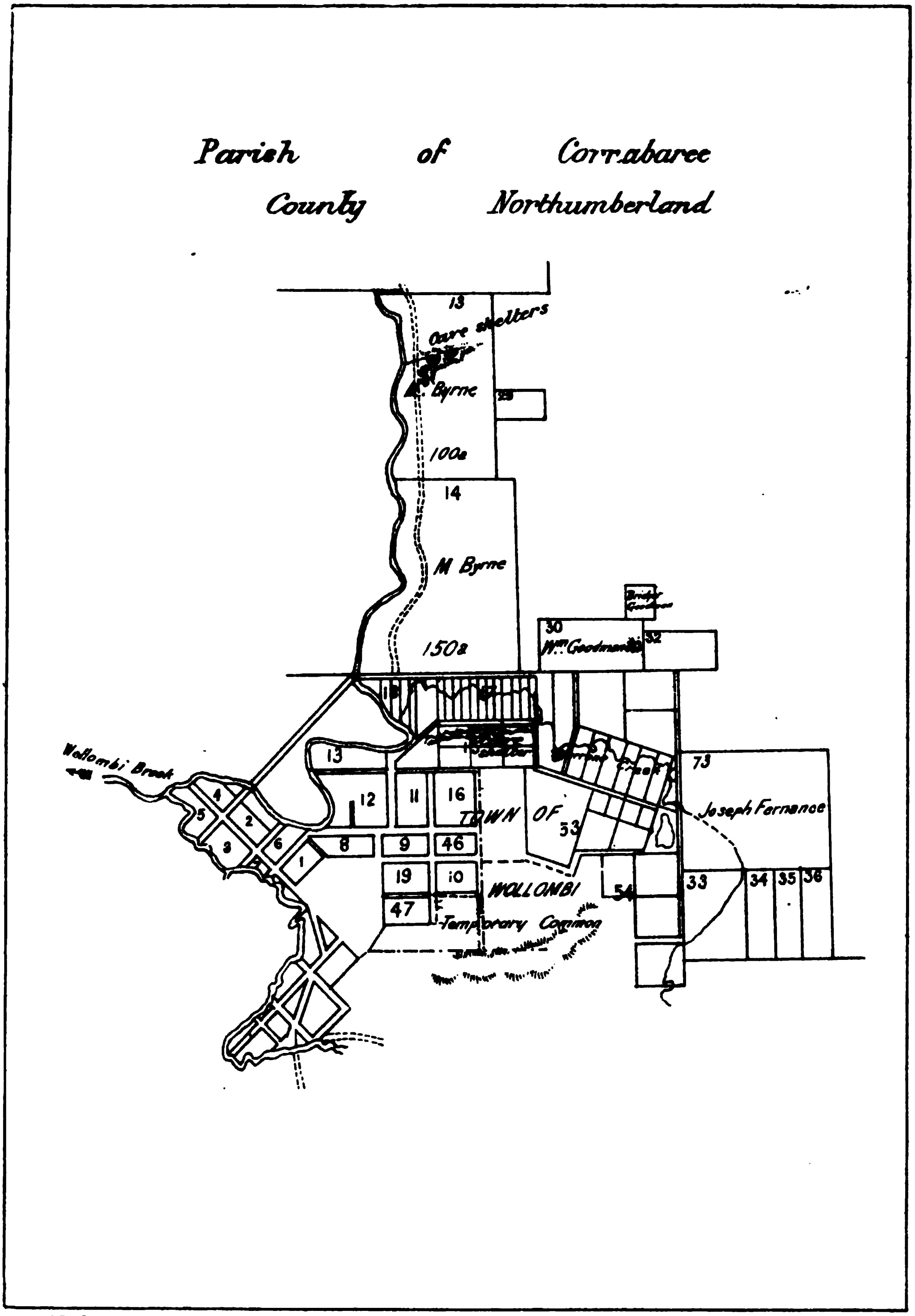

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PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE XIV.

Wollombi Cave-shelters.

Fig. 1. Transverse section of No. 1 Cave-shelter, showing the small entrance, and flood deposit on the floor.

Fig. 2. Longitudinal section of the same.

Fig. 3. Transverse section of No. 2 Cave-shelter.

Drawn by Mr. P. T. Hammond.

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RECORDS—GEOL. PLATE XIV.

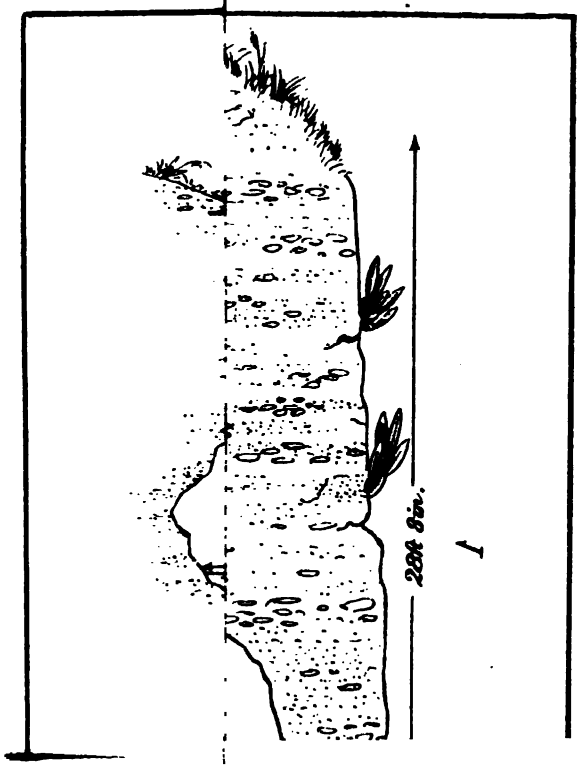

PLATE XV.

Aboriginal Drawings, Wollombi Rock-shelters.

Group to left—This represents a drawing, probably of the sun, surrounded by hands and feet, the former being principally the right. One, nearly in the middle line, shows how the operation had been interrupted, and the hand replaced in a slightly different position.

Upper right-hand figure represents a shield with an imperfect hand placed across the middle.

Right-hand figure is that of a well-formed boomerang.

Middle right-hand figure shows a hand probably intended to be holding a tomahawk.

Lower right-hand figure—A group of hands, possibly female.

Drawn from nature by Mr. P. T. Hammond.

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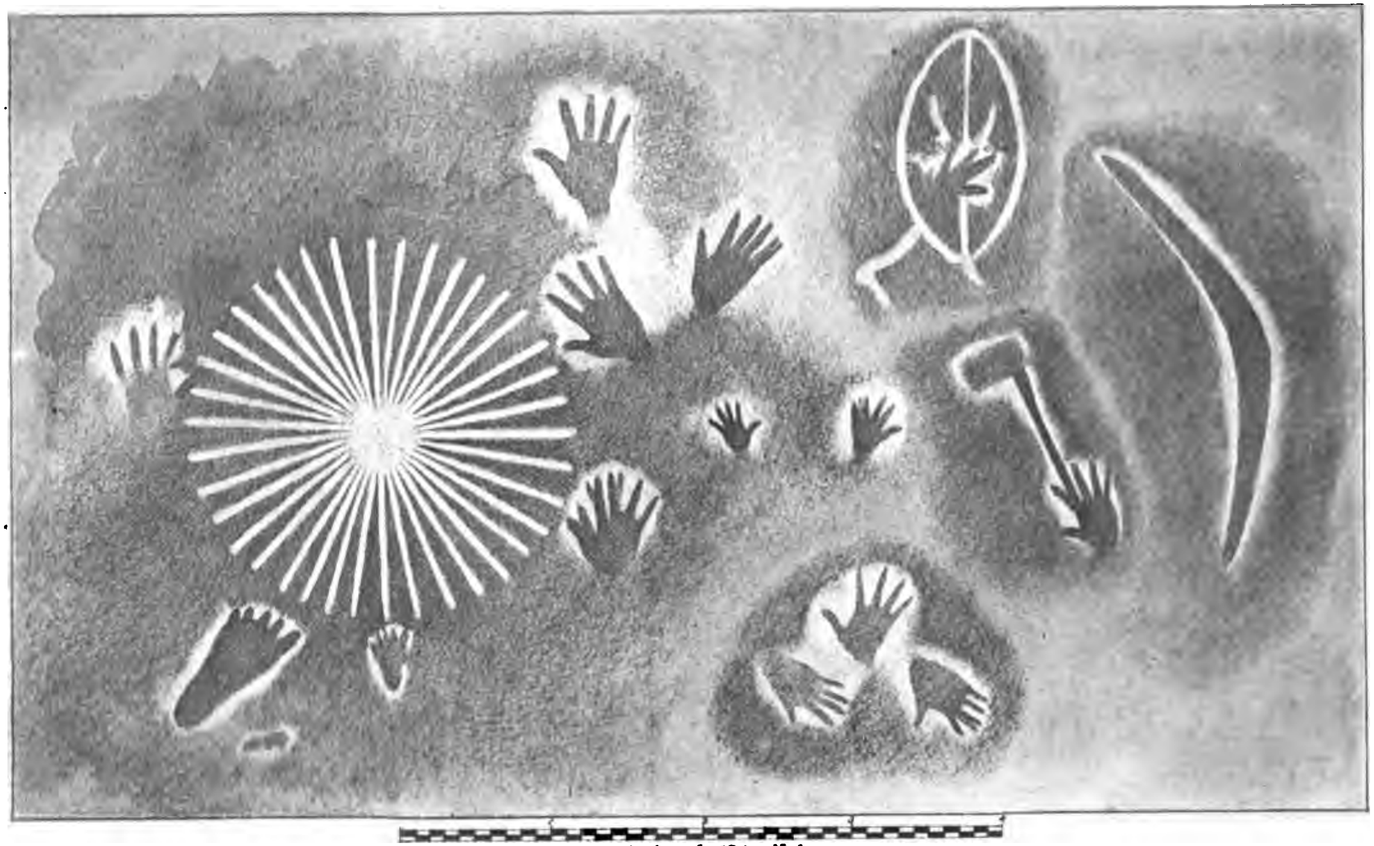

Scale 1 in. to 10 in. Nat.

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PLATE XVI.

Fig. 1. Large Fish, twenty-four feet long, indented partly on the sandstone table and partly on a rounded inclined surface.

Fig. 2. Another Fish, lying at right angles to Fig. 1. It is thirty-one feet nine inches long.

Fig. 3. An extraordinary Fish, sub-parallel to Fig. 2, and more or less below Fig. 1, sixteen feet nine inches in length. Within its outline is that of a Man, Fig 8.

Fig. 4. A Shield of the usual type pourtrayed in idiographic carvings.

Fig. 5. A Shield with expanded apices, gathered or puckered together.

Fig. 6. Rude figure of a Kangaroo, seven feet in height.

Fig. 7. Well-executed figure of a smaller Kangaroo.

Fig. 8. Figure of a Man, possessing all the peculiarities of aboriginal authorship.

Fig. 9. Group of objects in a depression on the sandstone table.

9^a. A Fish, probably a "hammer-headed shark," five feet in length.

9^b,—9^e. Objects of unknown affinity.

9^f. A Fish, with the head marked off by a diagonal line.

9^g. A Fish, with a wide gape.

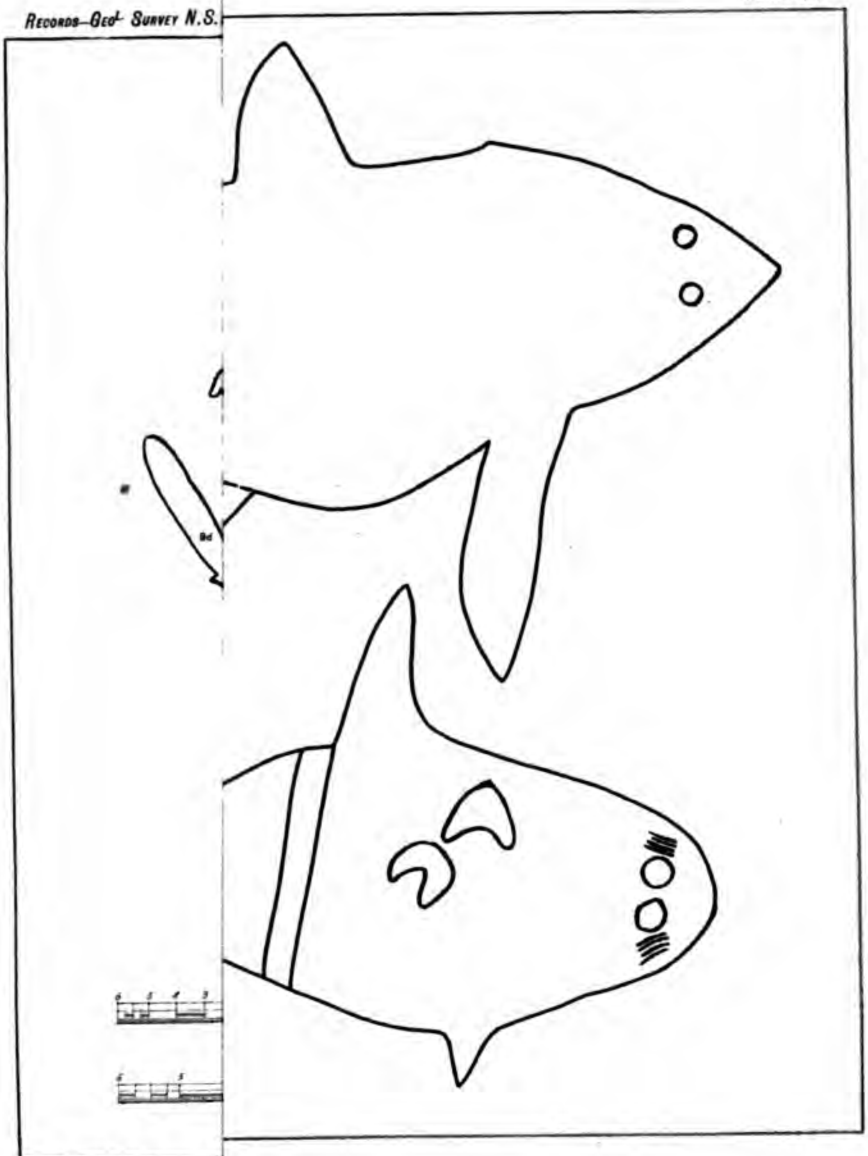
9^h. Unknown body, but allied to Figs. 9^b 9^e.

9^i. Perhaps intended for a "flying squirrel."

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

Records—Geol Survey N.S.

Plate XVI.



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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. II, PART I.

1890.

CONTENTS.

N.B.—The map to illustrate Mr. W. Anderson's "Notes on the Tertiary Deep Lead at Tumbarumba" can be had on application at the Geological Branch, Department of Mines, Sydney.

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GEOLOGICAL MAPS AND PUBLICATIONS ISSUED BY THE DEPARTMENT OF MINES, SYDNEY.

(1.) MAPS.

Map showing Mineral Areas of New South Wales. Scale, 8 miles to 1 inch.
Do do do Scale, 50 miles to 1 inch.
Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
Do do do do Scale, 22 miles to 1 inch.
Geological Map of the Districts of Hartley, Bowenfells, Wallerawang, and Rydal, by C. S. Wilkinson, L.S., F.G.S.
Geological Map of Hill End and Tambaroora, by E. F. Pittman, Geological Surveyor.
Geological Map of the Vegetable Creek Tin-mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor. Scale, 58 chains to 1 inch.
Index Map of the Vegetable Creek Tin-fields, by T. W. E. David, B.A., F.G.S. Scale, 80 chains to 1 inch.
Geological Map of the Forest Reefs District, by H. Y. L. Brown, Geological Surveyor.
Map of the Silver-mining Country, Barrier Ranges, by C. S. Wilkinson, L.S., F.G.S.
Vertical Sections of New South Wales Upper Coal Measures, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Diagrams showing the Thickness, Character, and Portion mined out of Coal-seams in the Coal Measures of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Plans showing the Outcrop, Thickness, and Dip of the Coal-seams in the Northern, Southern, and Western Coal-mining Districts of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Geological Sketch Map showing boundary of the Cretaceo-Tertiary Formation in the County of Cowper, by William Anderson, Geological Surveyor, 1889.
Geological Sketch Map of Tertiary Deep Lead, Tumberumba, by William Anderson, 1890.

(2.) PUBLICATIONS.

The Mining Act of 1884, with Regulations.
Annual Reports from 1875 to 1887 inclusive.
Mines and Mineral Statistics, 1875.

MINERAL PRODUCTS OF NEW SOUTH WALES, 1882, containing:—

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of Now South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

MINERAL PRODUCTS OF NEW SOUTH WALES, 2nd Edition, 1886, containing:—

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. The Collieries and Boghead Mineral Mines of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal Fields.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Geology.

1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.

Palæontology.

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales; and Australian Museum, Sydney. (4to. Sydney, 1888.)
2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)
3. Geological and Palæontological Relations of the Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in Eastern Australia and Tasmania, by Ottokar Feistmantel, M.D. (4to. Sydney, 1890.)
4. The Fossil Fishes of the Hawkesbury Series at Gosford, by A. S. Woodward, &c. (4to. Sydney, 1890.)

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Vol. I (Sydney, 1889-90).

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. II, PART II.

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